THESIS

FOR THE AWARD OF DEGREE OF

DOCTOR OF MEDICINE

SESSION 2020-2023

"A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad"

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LIST OF ABBREVIATIONS

%	:	Percentage
BMWM	:	Bio Medical Waste Management.
HCF	:	Health Care Facility.
MWHs	:	Medical Waste Handlers.
COVID-19	:	Corona virus disease-19
HCP	:	Health care professionals
MOHFW	:	Ministry of Health and Family Welfare
PEP	:	Post Exposure Prophylaxis
PPE	:	Personal Protective Equipment
MWM	:	Medical Waste Management.
HCWM	:	Health Care Waste Management
HCW	:	Health Care Workers
HBV	:	Hepatitis B Virus
HCV	:	Hepatitis C Virus
HIV/ AIDS	:	Human Immunodeficiency Virus/ Acquired Immunodeficiency Syndrome
MWTA	:	Medical Waste Tracking Act.
HCW	:	Health Care Waste.
HWM	:	Hospital Waste Management.
BMW	:	Bio Medical Waste
BWH	:	Biomedical Waste Hazardous.
MTP_A	:	Medical Termination of Pregnancy Act.
CPCB	:	Central Pollution Control Board
MOEFCC	:	Ministry of Environment, Forest & Climate change
CBWTF	:	Common Biomedical Waste Treatment Facilities
KAP	:	Knowledge Attitude Practice
ANM	:	Auxiliary Nurse Midwife
GNM	:	General Nursing Midwifery
DMLT	:	Diploma in Medical Laboratory Technology

SS	:	Sanitary Staff
CHC	:	Community Health Centre
PHC	:	Primary Health Centre
NaClO	:	Sodium Hypochlorite
WHO	:	World Health Organization
BOD	:	Biochemical Oxygen Demand
COD	:	Chemical Oxygen Demand

ANNEXURE-I

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List of Health Care Facilities

List of Community Health Centers.

- Community Health Centers, Muradnagar.
- Community Health Centers, Dasna.
- Community Health Centers, Modinagar.
- Community Health Centers, Loni.

List of Primary Health Centers.

- Primary Health Centers,Kakra.
- Primary Health Centers,Gyaspur.
- Primary Health Centers,Surana.
- Primary Health Centers,Bamheta.
- Primary Health Centers,Duhai.
- Primary Health Centers,Bhaupur.
- Primary Health Centers,Bhojpur.
- Primary Health Centers,Faridnagar.
- Primary Health Centers, Todi
- Primary Health Centers,Chirori.
- Primary Health Centers,Farukhnagar.
- Primary Health Centers, Mandola

List of Sub-Centers.

- Sub-Centers Khimawati
- Sub-Centers Dhindar
- Sub-Centers Salemabad
- Sub-Centers Bindipur
- Sub-Centers Shahzadpur
- Sub-Centers Dindoli
- Sub-Centers Raoli Kalan
- Sub-Centers Suhana
- Sub-Centers Bhanera
- Sub-Centers Khidauran
- Sub-Centers Suthari
- Sub-Centers Manoli
- Sub-Centers Rewari
- Sub-Centers Bhadurpur
- Sub-Centers Bayana
- Sub-Centers Bhoodgari
- Sub-Centers Bhowapur

- Sub-Centers Dabarsi
- Sub-Centers Indergari
- Sub-Centers Jalalabad
- Sub-Centers Kanauja
- Sub-Centers Kusaliya
- Sub-Centers Manki
- Sub-Centers Masoori
- Sub-Centers Mohanpur
- Sub-Centers Morta
- Sub-Centers Begmabad
- Sub-Centers Budhana
- Sub-Centers Gadana
- Sub-Centers Khanjarpur
- Sub-Centers Fafarana
- Sub-Centers Amarala
- Sub-Centers Atrauli
- Sub-Centers Badayala
- Sub-Centers Joya
- Sub-Centers Kalchina
- Sub-Centers Mehmadpur
- Sub-Centers Nahali
- Sub-Centers Jawali
- Sub-Centers Shakalpura
- Sub-Centers Siroli
- Sub-Centers Tila Shahabazpur
- Sub-Centers Asalatpur
- Sub-Centers Mehmudpur
- Sub-Centers Nistoli
- Sub-Centers Rajpur
- Sub-Centers Sirora
- Sub-Centers Agrola
- Sub-Centers Khanpur
- Sub-Centers Mirpur

ANNEXURE-III
INFORMED CONSENT

S. No:

Name of the Health care worker: Age:

Address: Phone number:

Date:

I have been explained the details of the study entitled **'A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad'** and my questions regarding the study have been answered to my satisfaction in a language understood by me.

1. I understand that I have the right to withdraw from the study at any time and to decline to answer any particular question.
2. I understand that my participation in this study is confidential and that no material that could identify me will be used in the analysis and in any reports based on this study.

I hereby provide my consent to participate in the study entitled **'A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad'**

Signature/ Thumb impression of the subject

Signature/ Thumb impression of the witness

सूचित सहमति

क्रमांक:
स्वास्थ्य कर्मी का नाम: आयु:
पता: फ़ोन नंबर:
दिनांक:

मुझे **'A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad'** शीर्षक के अध्ययन का विवरण समझाया गया है और अध्ययन के संबंध में मेरे सवालों का जवाब मेरी संतुष्टि के लिए एक भाषा में दिया गया है।

1. मैं समझता हूं कि मुझे किसी भी समय अध्ययन से हटने और किसी विशेष सवाल का उत्तर देने से इनकार करने का अधिकार है।

2. मैं समझता हूं कि इस अध्ययन में मेरी भागीदारी गोपनीय है और इस अध्ययन पर आधारित किसी भी रिपोर्ट में विश्लेषण और किसी भी रिपोर्ट में मेरी पहचान करने वाली किसी भी सामग्री का उपयोग नहीं किया जाएगा।

मैं इसके द्वारा **'A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad'** शीर्षक के अध्ययन में भाग लेने के लिए अपनी सहमति प्रदान करता हूं।

विषय के हस्ताक्षर/अंगूठे का निशान

गवाह के हस्ताक्षर/अंगूठे का निशान

ANNEXURE –IV

Questionnaire

Santosh Medical College

Study Title: A study on Knowledge and Practice of Biomedical Waste Management Amongthe Health Care Workers of Health Facilities of Distri Ghaziabad.

Interview Schedule

General Profile

1. Health Facilities
   - ◯ CHC (Community Health Center)
   - ◯ PHC (Primary Health Center)
   - ◯ Sub-Center
2. Name of the Health care worker_____
3. Age_____
4. Gender
   - ◯ Male
   - ◯ Female
5. Education
   - ◯ Post Graduate
   - ◯ Graduate
   - ◯ Diploma
   - ◯ 12th Pass
   - ◯ 10th Pass
6. Occupation
   - ◯ Doctor
   - ◯ Nurse
   - ◯ Lab Technician
   - ◯ Sanitary Staff

Knowledge regarding biomedical waste management

K1. Are you aware of Biomedical waste management?

- ◯ Yes
- ◯ No

K2. Are you aware of Hospital Waste Management & Handling Rule?

- ◯ Yes
- ◯ No

K3. Do you know when Biomedical waste (Management & Handling) Rule were first proposed?

- ◯ 1997
- ◯ 1998
- ◯ 1999
- ◯ 2000

K4. New classification of Bio-medical waste as per the revised Biomedical Waste Management rule came in which year?

- ◯ 2015
- ◯ 2016
- ◯ 2017
- ◯ 2018

K5. Do you know the different color coding for the biomedical waste as per Biomedical waste management Rule 2016?

- ◯ Yes
- ◯ N0

K6. Do you know about the agency that regulate Biomedical waste at your health care facilities?

- ◯ State
- ◯ Private
- ◯ No regulation
- ◯ Don't know

K7. Are you aware of biomedical waste hazards?

- ◯ Yes
- ◯ No

K8. If yes, what are the diseases that can be cause by biomedical waste if not disposed safely?

- ◯ HIV/ AIDS
- ◯ Hepatitis-B
- ◯ Both
- ◯ None of above

K9. Are you aware of precaution to be taken while biomedical waste handling?

- ◯ Yes
- ◯ No

K10. If yes, what precautions do you think one should be taking?

- ☐ Gloves
- ☐ Mask
- ☐ Goggle
- ☐ Personal protective apron

K11. Do you think, wearing a PPE can reduce risk of infection?

- ◯ Yes
- ◯ No

K12. As per the Bio Medical Waste Management Rules, 2016, any hazardous event should be reported/forwarded within?

- ◯ 12 hour
- ◯ 24 hour
- ◯ 48 hour
- ◯ 72 hour

K13. What should be the thickness of a plastic sheets provided inside the different bins?

- ◯ 25mm
- ◯ 50mm
- ◯ 70mm
- ◯ 75mm

K14. According to biomedical waste (Management & Handling) Rule, waste shoul not be stored beyond?

- ◯ 12 hour
- ◯ 24 hour
- ◯ 48 hour
- ◯ 72 hour

K15. Pre-treated vacutainers/vials containing blood samples are handed over to agency in which color category waste?

- ◯ Red
- ◯ Blue
- ◯ Yellow
- ◯ Black

K16. Is general waste collected in yellow bin?

- ◯ Yes
- ◯ NO

K17. Most important aspect of Bio Medical Waste management is?

- ◯ Segregation
- ◯ collection
- ◯ Transportation
- ◯ Storage

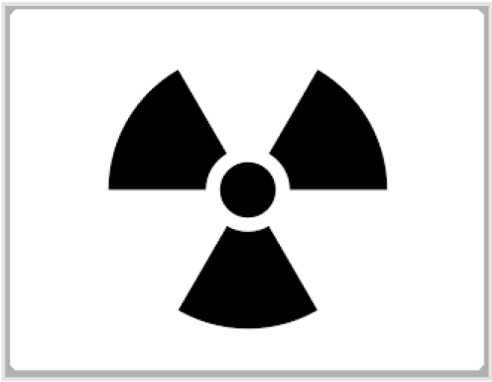
K18. How should the infectious waste collected in yellow bag be treated?

- ◯ Deep Burial
- ◯ Incinerator
- ◯ Microwaving
- ◯ Land Fill

K19. What are the highly infectious waste that are pre-treated onsite before sending for final treatment or disposal?

- ◯ Anatomical waste
- ◯ Laboratory Waste
- ◯ Metallic Body Implant
- ◯ Expired Medicine

K20. what is the symbol for Biohazard?



(a)

(b)

◯ (c)

◯ (d) Don't know

K21. Do you know how to prepare 1L of 1% Sodium hypochlorite from available 5% strength?

◯ Yes

◯ No

K22. What is the color code for dustbin that is being currently followed?

◯ Yellow, Green, Red, Blue

◯ Yellow, Red, Blue, Black

◯ Yellow, Red, Blue, White

◯ Yellow, Red, Purple, White

K23. Who regulates the safe transport of Biomedical Waste?

- ◯ Pollution Control Board of India
- ◯ Transport Corporation of India
- ◯ Private Corporation
- ◯ Don't know

Practice regarding biomedical waste management

P1. Is Bio medical waste management being handled properly in your setup?

- ◯ Yes
- ◯ No

P2. Are you following the revised biomedical waste management rule in your setup?

- ◯ Yes
- ◯ No

P3. Do you follow the color coding of the biomedical waste management rule?

- ◯ Yes
- ◯ No

P4. Do you separate/segregate different type of hospital waste?

- ◯ Yes
- ◯ No

P5. Since when the new color coding of the biomedical waste management rule is being followed in your setup?

- ◯ 2015
- ◯ 2016
- ◯ Don't know
- ◯ Not followed in our setup

P6. How do you collect different type of hospital waste?

- ◯ In separate color coded bag or container
- ◯ In single bag or container
- ◯ No collection
- ◯ Don't know

P7. Do you label hazardous waste separately, present in your health facilities?

- ◯ Yes
- ◯ No

P8. Do you weigh the biomedical waste generated in your health facilities?

- ◯ Yes
- ◯ No

P9. Do you wear PPE (Personal Protective Equipment) while handling Bio Medical Waste management?

- ◯ Yes
- ◯ No

P10. Do you use puncture-proof plastic/cardboard container to collect waste sharp?

- ◯ Yes
- ◯ No

P11. For how long you store biomedical waste in your setup?

- ◯ 12 hour
- ◯ 24 hour
- ◯ 48 hour
- ◯ 72 hour

P12. What is the thickness of a plastic sheets provided in your health facility for different bins?

- ◯ 25mm
- ◯ 50mm
- ◯ 70mm
- ◯ 75mm

P13. Do you have a system of reporting injuries and accident happen due to Biomedical waste?

- ◯ Yes
- ◯ No

P14. How much time was taken report any hazardous event in your setup occurred due to Bio Medical waste?

- ◯ 12 hour
- ◯ 24 hour
- ◯ 48 hour
- ◯ No such event occurred

P15. Have you been immunized against Hepatitis B?

- ◯ Yes
- ◯ No

P16. Do you follow PEP (Post exposure prophylaxis) after needle stick injury or percutaneous injury?

- ◯ Yes
- ◯ No

P17. Do you put infectious waste in black container?

- ◯ Yes
- ◯ No

P18.How do you prepare 1L of 1% Sodium hypochlorite from available 5% strength?

- ◯ 1000ml of water + 500ml of Sodium hypochlorite
- ◯ 800ml of water + 200ml of Sodium hypochlorite
- ◯ 500ml of water + 200ml of Sodium hypochlorite
- ◯ 250ml of water + 500ml of Sodium hypochlorite

P19. Do you maintain a register for Biomedical waste disposal in your setup?

- ◯ Yes
- ◯ No

P20. In your health facility which agency is assigned for safe transport of Bio Medical Waste management?

- ◯ State
- ◯ Private
- ◯ No regulation
- ◯ Don't Know

P21. What precautions do you take while handling Bio medical waste?

Tick whatever apply.

- ☐ Gloves
- ☐ Mask
- ☐ Goggle
- ☐ Personal protective apron

Associated factor with respect to COVID19

A1. Personal protective equipment used in COVID19 like goggles, face shield and gloves are disposed in?

- ◯ Red bin
- ◯ Yellow bin
- ◯ Black Bin
- ◯ Don't know

A2. Personal protective equipment used in COVID19 like Used mask (N95) are disposed in?

- ◯ Yellow bin
- ◯ Red bin
- ◯ Black Bin
- ◯ Don't know

A3. How many layered bags are used for collection of waste from COVID-19 to ensure zero-leaks?

- ◯ Single
- ◯ Double
- ◯ Triple
- ◯ Don't know

A4. Biomedical waste generated from COVID-19 related activities should be strictly disposed of within?

- ◯ 12 hour
- ◯ 24 hour
- ◯ 48 hour
- ◯ Don't know

A5. Health care worker working in a COVID ward should dispose of the plastic overall in_____.

- ◯ Red bin
- ◯ Yellow bin
- ◯ Black Bin
- ◯ Don't know

A6. Inner & outer surface of Bio-Medical Waste containers from COVID 19 must be disinfected daily with?

- ◯ 0.5% Formaldehyde
- ◯ 1 % Sodium Hypochlorite
- ◯ 2% Methyl Bromide
- ◯ Don't know

A7. Is it mandatory for all Bio-Medical Waste bags & containers from COVID 19 area to carry COVID 19 Waste label?

- ◯ Yes
- ◯ No

A8. What is the name of the App developed by the State pollution control board for the record of BMW generated from COVID-19?

- ◯ COVIN BMW
- ◯ COVID19BMW
- ◯ AROGYA SETU
- ◯ Don't know

A9. What is the method for handling Bio medical waste, generated from COVID19 by remote quarantine centers in rural area?

- ◯ Microwaving
- ◯ Deep Burial
- ◯ Recycling
- ◯ Don't know

A10. Do you have separate color coded bin with foot operated lids for Bio-Medical Waste generated from COVID 19?

- ◯ Yes
- ◯ No

A11. Do you maintain separate record of waste generated from COVID-19?

- ◯ Yes
- ◯ No

A12. Does your health center have dedicated sanitation workers deputed only for collection of COVID 19 Biomedical waste?

- ◯ Yes
- ◯ No

A13. Did you attend any government certified training regarding Hospital Waste Management & Handling?

- ◯ Yes
- ◯ No

A14. Does your center have any facility for storage of Bio- medical waste?

- ◯ Yes
- ◯ No

A15. Are any banner/chart showing Biomedical waste collection, segregation & disposal present in your health facility?

- ◯ Yes
- ◯ No

.....

.....**THANK YOU**.....

Introduction

INTRODUCTION

Health-care waste (HCW) is a serious problem, which frequently causes water, air and soil pollution along with dreaded nosocomial diseases.[1]

In the past few decades many countries have experienced a tremendous expansion in health care system across the world. Consequently, more people are now receiving better healthcare across a wider geographic area which additionally resulted in higher generation of Bio-Medical waste.[2]

Any site/location where human population is diagnosed, treated, or immunised, regardless of the scope and nature of the health care setup along with associated research work is called a Health Care Facility (HCF). Government run facilities may include small centres like sub-centre, primary health centres to larger facilities like district hospitals and community health centres. While private institutions range in size from small private clinics to corporate hospitals.[3]

Because of improper waste management, an HCF may be a source of illnesses, infections, and negative environmental effects. Every healthcare facility must manage biomedical waste in order to protect the environment. Healthcare establishments need to follow waste management rules appropriately.[4]

Regrettably, advances in healthcare activities have resulted in an ever-increasing amount of waste that is not being properly treated.[5]

The term "biomedical waste" (BMW) has been defined by the Government of India's Biomedical Waste (Management and Handling) Rules 2016 as "any waste generated during diagnosis, treatment, or immunisation of humans or animals, or in research activities pertaining thereto, or in the production or testing of biologicals.".[6]

Every year, 16 billion injections are given around the world. There is an increased risk of infection and injury as a result of improper disposal of the used needles and syringes. Every year approximately 1.7 million hepatitis B, 315,000 hepatitis C viral infections and 33,800 HIV infections occur in low-income countries due to poor waste management.[7] Despite the negative effects of bio-medical waste on human health and environment, proper medical waste management is not up to the mark in many developing countries.[8]

Exposure to hospital-generated waste poses a serious risk to both patients and hospital staff with a negative impact on public health.[9] Appropriate waste management requires an active involvement by the medical waste handlers (MWHs). They play an important role in waste disposal. For suitable handling of bio-medical wastes, the waste handlers should have a good understanding and positive attitude towards the handling rules and techniques.

Numerous studies have amply demonstrated the grave health risks that improper biomedical waste disposal poses to hospital employees, rag pickers, municipal workers, and the general public. The significant prevalence of illnesses like HIV, Hepatitis B and C adds to this threat.[10] It has been determined that hospital-acquired infections act as a chief indicator for inappropriate waste handling.[11] Medical waste management has recently received international attention as a result of increased awareness of HBV, HCV and HIV [12-13]. More than 30 extremely contagious blood-borne pathogens can spread through medical waste.[14]

Segregation, collection, storage, transport, treatment, and disposal are crucial processes in acceptable Medical Waste Management (MWM). Therefore, the employees of healthcare institutions must have the necessary knowledge, attitudes, and behaviours in order to follow best practices in waste management. [15]

Even before the coronavirus pandemic hit the global population, just 27% of health-care facilities were providing the biomedical waste management services.[16] The waste generated by medical facilities worldwide increased nearly five times as a result of the pandemic. This volume overload has been exacerbated by an increment in the use of personal protective gear. The coronavirus outbreak has shown flaws in countries waste management procedures in addition to their inadequate medical setup and lack of pandemic preparedness.[17]

Government regulations on BMW are lacking in many nations. India was among the first nation to adopt and implement waste handling rules.[18] In accordance with the Environment Protection Act of 1986, the "Bio-Medical Waste Management and Handling

Rules" came into force in July 1998 which was later updated in 2003, 2011, and 2016.[19] Hospitals in India have not met the expected criteria for BMWM practises despite a decade of implementation.[20-21] These potentially dangerous wastes have a high pathogenicity, or capacity to spread illness, and they may not respond to therapy.[22] The BMW classifications and treatment methods are listed in Schedule 1 of the Biomedical Waste Rules of 2016. Standards for the handling of biological waste are included in Schedule 2. Schedule 3 lists the specified authorities and their accompanying responsibilities. Schedule 4 includes labels for bags or containers used to store biological waste.[23]

Safe waste disposal and community protection from various harmful impacts of hazardous waste can be achieved with the help of sufficient information, appropriate methods, and safety precautions.[24] Health care providers may also be a possible source of infection. Medical waste handlers frequently experience occupational health risks as a result of poor waste management practises and working in a highly risky environment.[25] The key to protecting people from potentially hazardous substances is adequate information, a positive attitude, and good waste disposal methods.[26]

Many nations dispose their BMW in dustbins with regular household waste. Some even reuse sharps and syringes, raising the risk of infection, especially in post pandemic situation.[27] Moreover, it has been noted that improper segregation at the point of origin results in the mixing of infectious and non-infectious waste.[28] BMW should be distinguished by colour-coding systems that should be strictly followed. The recent COVID-19 pandemic has significantly accelerated global BMW generation. Despite the fact that the WHO has specific guidelines for waste management in both pandemic and normal health situations, it is very challenging to follow the rules in this current emergency. More so far, the developing countries like India.[29] Wastes from COVID-19 wards should be collected separately, and transferred directly to treatment facilities to avoid cross-contamination.[30-31] Even though the amount of waste generated by CHCs, PHCs appears to vary, it is believed that even a small amount of infectious

material can transmit the disease more rapidly in rural areas than in urban areas due to inadequate waste disposal facilities.[32]

India generates 600 metric ton of BMW every year.[33] Small-scale incinerators have been used as a temporary solution in less developed and developing countries due to the lack of appropriate waste disposal options. Particulate matter like mercury, dioxin, and furans are few of the toxic pollutants that incinerators release into the environment.[34] The HCW management (HCWM) situation in India is well below the required level, its causes include a lack of qualified employees, insufficient health infrastructure, and inadequate HCWM knowledge and application by healthcare professionals.[35]

Although there are legal regulations (BMWM Rules 1998) to lessen the effects of infectious and hazardous hospital waste on the public, these regulations have not yet been fully applied.[2]

The most serious issues with healthcare waste include the lack of effective waste management, a lack of knowledge about the health risks posed by biological wastes, a lack of sufficient financial and human resources, and poor waste disposal regulation.[36] If these wastes are not handled adequately, the dangerous effects of medical waste on the general public and the environment will be multiple. Hospital waste management has a wide range of health consequences for patients, healthcare professionals (doctors, nurses, sanitary staff, etc.), and the general public.[37]

Therefore, the objectives of this study were to assess the knowledge and practice regarding BMW management among Health care worker during COVID-19 crisis in Ghaziabad district and to find out the associated factors regarding knowledge and practice level with the selected demographic variables.

Aims and Objective

AIMS AND OBJECTIVE

The study entitled "A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad" was conducted in health care facilities of rural area of Ghaziabad with the following Aim and Objectives.

Aim: - To Assess the Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities in District Ghaziabad with the following objectives

Objectives: -

1. To assess the Knowledge regarding biomedical waste management among Doctors, Nurses and other Paramedical staffs working in health facilities in district Ghaziabad.

2. To assess the practice regarding biomedical waste management among Doctors, Nurses and other Paramedical staffs working in health facilities in district Ghaziabad.

3. To find out associated factor with their knowledge & practice regarding Biomedical Waste management.

Review of Literature

REVIEW OF LITERATURE

A group of concerned individuals gathered in Bergen, Norway, in 1983, where the regional office of the World Health Organization for Europe convened the first discussion on the topic of management of medical waste. The difficult situation due to untreated hospital waste was highlighted during the summer of 1988 beach clean-ups. These were investigated by the Environmental Protection Agency of the United States and resulted in the passage of the Medical Waste Tracking Act (MWTA) in November 1988. Consequently, the United States became a pioneer in hospital waste management. [38]

The country's apex court, the Supreme Court of India has occasionally issued directives about hospital waste management in India. Ministry of Environment and Forests and Environment Protection Act of 1986 notified the Biomedical Waste Management and Handling Rules on July 27, 1998, in considering the preceding and in accordance with the court's order. In order to avoid legal action, all hospitals, are now bound to abide by these standards whether public or private.[39]

CLASSIFICATION OF HOSPITAL WASTE

(I) Classification of Bio-Medical Waste according to World Health Organization

The world health organization had adopted a functional classification in 1993, of hospital waste into eight categories based on hazard potentials, as follows; [40]

1. General Waste
2. Pathological
3. Radioactive
4. Chemical
5. Infectious to potentially infectious waste
6. Sharps
7. Pharmaceuticals
8. Pressurized containers

(II) Biomedical Waste was classified into 4 Categories by the Government of India as per Biomedical waste management and handling rule 2016 as follows [41]

Category	Type of Waste
Yellow	(a) Human Anatomical Waste (b) Animal Anatomical Waste (c) Soiled Waste (d) Expired or discarded Medicines (e) Chemical Waste (f) Chemical Liquid Waste (g) Discarded linen, mattresses, beddings contaminated with blood or body fluid (h) Microbiology, Biotechnology and other clinical laboratory Waste
Red	Contaminated Waste (Recyclable)
White	Waste Sharp Including metals
Blue	(a) Glassware (b) Metallic body Implants

Sources of Bio-medical waste

Major Sources of bio-medical waste.[40]

• Hospitals Government and Private/Nursing homes/ dispensaries.

• Medical colleges and research centres/paramedic services.

• Primary health centres

• Veterinary colleges and animal research centres.

• Laboratories and research centres

• Mortuary and autopsy centres

• Animal research and testing laboratories

• Production units.

• Biotechnology institutions.

• Blood banks and collection services

• Nursing homes for the elderly

Minor Sources of bio-medical waste.

• Physicians/ dentists' clinics

• Blood donation camps.

• Vaccination centres

• Animal houses/slaughter houses.

• Acupuncturists/psychiatric clinics/cosmetic piercing.

• Institutions for disabled persons

• Funeral services.

HOSPITAL WASTE GENERATION

In any medical procedure carried out in a health care set up, some amount of biomedical waste is generated.

Hospital waste depends on the type of health care facility, proportion of reusable and disposable items and the standardized implementation of national and hospital waste management policy[42].

MAGNITUDE OF PROBLEM

Various studies have been conducted at different places to access the quality of BMWM practice at various health Facilities within India.

In a study conducted by Wong KF, in Florida, USA, in 1994, it was observed that the main
problem concerning waste management is lack of communication and participation among
the involved people. Author observed the basic problem regarding waste management is the absence of communication between government and the communities. [43]

In 2012, at the International Conference held in Singapore on Environment Science and Engineering, Kamalakanta Mudulil and Akhilesh Barve discussed the health care waste management in India. They observed that majority of nursing homes and small-scale hospitals in India do not possess an efficient mechanism for disposing of their medical waste securely. On that conference, the World Health Organization (WHO) claims that India is on the brink of experiencing an HIV epidemic, along with adverse HIV and TB impact on human wellbeing. Additionally, number of Hepatitis B and C infections were rising. Hepatitis C contributed to an increase in mortality. Separating infectious waste from non-infectious waste was beneficial if adequate segregation procedures were followed. Lack of segregation practices increased the infectious medical waste, which when generated were mixed with non-infectious waste. As observed in Indian hospitals, there was poor waste segregation practice from waste generation to disposal. Segregating

waste at the site of generation was found to be useful, but as waste handlers were unaware of this, they combined all the waste during collection. This resulted in missing of the ultimate benefit of segregation. [44]

Rudraswamy S and Nagandini conducted a study in south America, North America and Europe. They evaluated that global hospital waste management scenario in 2013. They provide insight into the hospital waste management (HWM) scenario in both developed and developing nations. They believed that for the community's health and the protection of the environment, the safe treatment of medical waste is crucial[45].

An observational study was carried out in 2014 at a tertiary hospital in Navi Mumbai that was connected to a medical college by the author Pinto V.N, Joshi S.M, and Velankar D. They discussed the knowledge and attitudes of specialists, physicians, interns, and final-year nursing students on biomedical waste management. It was observed that their knowledge and attitudes about BMW management differed from person to person and were not matched to a satisfactory level. They came to the conclusion that a strategy involved in the practical training programme and awareness seminars about safe management of BMW for all hospital staff members, should be conducted with a particular emphasis on junior level staff. [46]

Amarpreet Singh Ghural, Dr. CM Sankaran Kutty conducted a study in Mumbai in 2013 on a “Corporate Responsibility Dilemma in India”. They studied various hospitals, dispensaries and healthcare centres in India and concluded that the society was facing many problems due to the infectious waste generated from the hospitals. They focused on awareness and education of harmful effects of the waste, the current status of discarding of biomedical waste in Mumbai and recommended some feasible strategies for managing the problem. [47]

Zarook M. has described bio medical waste to be extremely dangerous with a high potential for causing diseases. He has described various methods for managing biomedical medical waste. He claims that ability to manage and control medical waste is a skill that healthcare professionals should possess. [48]

In a systematic review done by Tabasi R and Marthandan G, in 2013 the author evaluated various studies on clinical waste management that demonstrated the volume of waste produced by various hospitals in different nations. They discovered that different hospital parameters were taken into consideration for calculating the rate of medical waste generation, such as the type, size, and number of departments in the facility. Along with number of beds, type of specialization, ratio of disposable items, and number of outpatients. They discovered that roughly 65 % of the hospitals demonstrated a strong relationship between hospital type and waste generation. [49]

A review done in 2012 on concerns about the consequences of biomedical waste management practices on people, their health, and the environment had been raised by Patan S, Mathur P, and Shobhawat A.S. Now it is acknowledged that the "Hospital waste" produced during patient care has many negative and damaging consequences on the environment, including humans. Hospital staff, the general public, and the surrounding flora and fauna along with the animals are at risk for health problems because of hospital waste. The issue of discarding the waste in various healthcare facilities were becoming increasingly serious. [50]

Bhagawati G conducted an observational study in 2013 where they interviewed the facility's physicians, nurses, lab. technicians, and other paramedical of the 600-beded hospital in Delhi. They found that only 17 percent of healthcare professionals as a whole were aware of different kind of BMW. [51]

Pullishery F carried out the study in 2014 with 157 health workers and students in various health facilities in and around Mangalore, Karnataka, including primary health centres, community health centres, nursing homes, dental clinics, veterinary clinics, and laboratories. None of the sanitary workers knew anything about the BMW. Of all the 157 Health care workers, only 34 correctly answered the questionnaire's colour coding. Even while the governing body demands of segregation of waste at source only, but many hospitals did not dispose of the waste in the required manner. [52]

According to a cross sectional study conducted by Gupta S in 2016 in Balrampur Hospital Lucknow, revealed contagious and not infected wastes were mixed, when

discarded in hospital surroundings and subsequently dumped with urban local body waste at disposal sites. Outside the patient wards, public bins are used to collect all waste types. The hospital relies on the kindness of the cities' municipality, whose staff typically picked up this waste every two or three days, to dispose it off. The hospital lacks an infectious waste treatment facility. The laboratory waste was directly dumped into the Gomti river without being properly disinfected. The rag pickers segregate disposable plastics from the mix of hospital and municipal waste. The sharps present in the hospital waste exposed the rag pickers to major health risks. [53]

In another study conducted by U. Jagadeesh Chandira Boss in 2016, in Puducherry, it was noticed that the Government General Hospital's collection and disposal of biomedical waste hazardous (BWH) had (a) No differentiation among the infectious and non-infectious waste (b) the waste collected was not adequately treated and transported along with municipal garbage and (c) inadequate knowledge and skills of the health workers to don on and off the PPE.[54]

The challenge with biomedical waste is not quantity, but rather its hazard and infectiousness. According to estimates, less than 60 metric tons of the 5000 metric tons of municipal waste are accounted for in cities like Delhi, for instance. Only 10-15% of it are hazardous and contaminated, requiring adequate protocol. The remaining 85% waste was non-hazardous and non-infectious in nature, necessitating no expensive treatment. Because of this, segregation was crucial for efficient biomedical waste management. [55]

To increase acceptance and adherence of sustainable disposal of BMW in the country, the "Bio-Medical Waste Management Rules,1998," were revised in 2016. Appropriate waste segregation is the cornerstone for a successful management of biomedical waste (BMW). Ineffective waste segregation techniques can harm the public's health and raise the cost of treatment. Continuous monitoring and training are effective ways to address shortcomings in waste segregation procedures. [56]

HOSPITAL WASTE SEGREGATION AND LABELLING

Segregation is the fundamental step of separation of various type waste categories generated at the different source, lowering the risk of hazards and expenses associated with waste management and disposal. The crucial most stage in managing the hospital waste is segregation. Effective biomedical waste management is only possible with effective segregation.[57]

According to the rules outlined in Schedule 1 of the "Biomedical Waste Management and handling Rules, 1998," of Government of India, such wastes must be segregated according to guidelines.

It was observed that the hospital waste is not properly segregated that is why it is very difficult to manage it. Central pollution control board conducted a study in 2008 in 66 major hospitals of Delhi stated that proper segregation of waste was not practiced except in a few hospitals. Rag pickers are playing a key role in segregation of wastes, which have some resale values. [58]

Waste segregation:

- Help in reducing the quantum of waste needing special handling and treatment
- Prevents the sharp waste to be mixed with general municipal waste.
- Stops unlawful reusage of waste like syringes, needles and other plastics.
- Minimizes the expenditure incurred in treating and disposing of hospital waste. (since 80% of it is general waste, not warranting any special treatment).[59]

Categories of Bio-Medical Waste, According to (Management & Handling) Rules, 1998 by MINISTRY OF ENVIRONMENT & FORESTS (New Delhi, 20th July, 1998).[60]

Option	Waste Category	Treatment & Disposal
Category No. I	Human Anatomical Waste (human tissues, organs, body parts)	Incineration/deep burial Category
Category No. 2	Animal Waste (animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospitals, animal)	Incineration / deep burial
Category No 3	Microbiology & Biotechnology Waste (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)	Local autoclaving / microwaving / incineration

Category No 4	Waste sharps (needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)	Disinfection chemical treatment /autoclaving / micro- waving and mutilation/ shredding"
Category No 5	Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)	Incineration /destruct ion and drugs disposal in secured landfills drugs disposal in secured
Category No 6	Solid Waste (Items contaminated with blood, and body fluids including cotton dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)	Incineration autoclaving / micro-waving
Category No. 7	Solid Waste (wastes generated from disposable items other than the waste sharps such as tubing, catheters, intravenous sets etc.).	Disinfection by chemical treatment by autoclaving/micro-waving and mutilation/ shredding

Category No. 8	Liquid Waste (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)	disinfection by chemical treatment and discharge into drains.
Category No. 9	Incineration Ash (ash from incineration of any bio-medical waste)	Disposal in municipal landfill
Category No. 10	Chemical Waste (chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.)	Chemical treatment and discharge into drains for liquids and secured landfill for solids

COLOUR CODING AND TYPE OF CONTAINER FOR SEGREGATION OF BIO-MEDICAL WASTES in 1998.

Colour Coding	**Type of Container**	**Waste Category**	**Treatment options as per Schedule I (1998)**
Yellow	Plastic bag	Cat. 1, Cat. 2, and Cat. 3, Cat. 6.	Incineration/deep burial
Red	Disinfected container/plastic bag	Cat. 3, Cat. 6, Cat.7.	Autoclaving/Microwaving/ Chemical Treatment
Blue/White translucent	Plastic bag/puncture proof Container	Cat. 4, Cat. 7.	Autoclaving/Microwaving/ Chemical Treatment and destruction/shredding
Black	Plastic bag (solid)	Cat. 5 and Cat. 9 and Cat. 10.	Disposal in secured landfill

BIOMEDICAL WASTE CATEGORIES AND THEIR SEGREGATION, COLLECTION, TREATMENT, PROCESSING AND DISPOSAL METHOD AS PER THE RULE IN 2016 [61]

Category	**Type of Waste**	**Treatment and Disposal options**	**Type of Bag or Container to be used**
Yellow	(a) Human Anatomical Waste: Human tissues, organs, body parts and fetus below the viability period (as per the Medical Termination of Pregnancy Act 1971, amended from time to time).	Incineration or Plasma Pyrolysis or deep burial	Yellow coloured non-chlorinated plastic bags
	(b)Animal Anatomical Waste : Experimental animal carcasses, body parts, organs, tissues, including the waste generated from animals used in experiments or testing in veterinary hospitals or colleges or animal houses.	Incineration or Plasma Pyrolysis or deep burial	Yellow coloured non-chlorinated plastic bags
	(c) Soiled Waste: Items contaminated with blood, body fluids like dressings, plaster casts, cotton swabs and bags containing residual or discarded blood and blood components.	Incineration or Plasma Pyrolysis or deep burial. In absence of above facilities, autoclaving or micro-waving/hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery.	Yellow colored non-chlorinated plastic bags

	(d) Expired or Discarded Medicines: Pharmaceutical waste like antibiotics, cytotoxic drugs including all items contaminated with cytotoxic drugs along with glass or plastic ampoules, vials etc.	Expired `cytotoxic drugs and items contaminated with cytotoxic drugs to be returned back to the manufacturer or supplier for incineration at temperature >12000 C or to common bio-medical waste treatment facility or hazardous waste treatment, storage and disposal facility for incineration at >12000 C or Encapsulation or Plasma Pyrolysis at >12000 C. All other medicines shall be either sent back to manufacturer or disposed by incineration.	Yellow colored non-chlorinated plastic bags or containers
	(e) Chemical Waste: Chemicals used in production of biological and used or discarded disinfectants.	Disposed of by incineration or Plasma Pyrolysis or Encapsulation in hazardous waste treatment, storage and disposal facility.	Yellow colored containers or non-chlorinated plastic bag

	(f) Chemical Liquid Waste : Liquid waste generated due to use of chemicals in production of biological and used or discarded disinfectants, Silver X-ray film developing liquid, discarded Formalin, infected secretions, aspirated body fluids, liquid from laboratories and floor washings, cleaning, house-keeping and disinfecting activities etc.	After resource recovery, the chemical liquid waste shall be pre-treated before mixing with other wastewater.	Separate collection system leading to effluent treatment system
	(g) Discarded linen, mattresses, beddings contaminated with blood or body fluid.	Non- chlorinated chemical disinfection followed by incineration or Plasma Pyrolysis or for energy recovery. In absence of above facilities, shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent for energy recovery or incineration or Plasma Pyrolysis.	Non-chlorinated yellow plastic bags or suitable packing material
	(h) Microbiology, Biotechnology and other clinical laboratory waste: Blood bags, Laboratory cultures, stocks or specimens of microorganisms, live or attenuated vaccines, human and animal cell cultures used in research, industrial laboratories, production of biological, residual toxins, dishes and devices used for cultures.	Pre-treat to sterilize with no chlorinated chemicals on-site as per National AIDS Control Organization or World Health Organization guidelines thereafter for Incineration.	Autoclave safe plastic bags or containers

Red	Contaminated Waste (Recyclable) (a) Wastes generated from disposable items such as tubing, bottles, intravenous tubes and sets, catheters, urine bags, syringes (without needles and fixed needle syringes) and vacutainers with their needles cut) and gloves.	Autoclaving or micro-waving/ hydroclaving followed by shredding or mutilation or combination of sterilization and shredding. Treated waste to be sent to registered or authorized recyclers or for energy recovery or plastics to diesel or fuel oil or for road making, whichever is possible. Plastic waste should not be sent to landfill sites.	Red colored non-chlorinated plastic bags or containers
White (Translucent)	Waste sharps including Metals: Needles, syringes with fixed needles, needles from needle tip cutter or burner, scalpels, blades, or any other contaminated sharp object that may cause puncture and cuts. This includes both used, discarded and contaminated metal sharps	Autoclaving or Dry Heat Sterilization followed by shredding or mutilation or encapsulation in metal container or cement concrete; combination of shredding cum autoclaving; and sent for final disposal to iron foundries (having consent to operate from the State Pollution Control Boards or Pollution Control Committees) or sanitary landfill or designated concrete waste sharp pit.	Puncture proof, Leak proof, tamper proof containers

Blue	(a) Glassware: Broken or discarded and contaminated glass including medicine vials and ampoules except those contaminated with cytotoxic wastes.	Disinfection (by soaking the washed glass waste after cleaning with detergent and Sodium Hypochlorite treatment) or through autoclaving or microwaving or hydroclaving and then sent for recycling.	Cardboard boxes with blue colored marking
	(b) Metallic Body Implants		Cardboard boxes with blue coloured marking

LABELLING OF HOSPITAL WASTE

Proper labelling is important for the correct identification and safe regulation of Biomedical wastes. It also warns all workers, patients and public regarding the existence of the waste product. Labels for bio-medical waste containers/bags:

LABEL FOR BIO-MEDICAL WASTE CONTAINERS or BAGS

HANDLE WITH CARE

CYTOTOXIC HAZARDSYMBOL

HANDLE WITH CARE

- All symbols and words are to be easily legible (size of symbols and letters to be 80 mm.)
- The labels should be completed using ink that does not wash off.

In a study conducted by Joe Joseph in 2004 in Pondicherry, India, it was found that majority of the hospitals (74%) were not using any colour- coding and a very small number (15%) were using the bio-hazard symbol. [62]

HOSPITAL WASTE TRANSPORT AND STORAGE

Biomedical wastes need to be stored if immediate treatment and disposal is not possible. According to the rules, infectious wastes cannot be stored for more than 48 hours because wastes start harbouring microorganisms. [57]

Storage may be at the waste generator facility itself or off-site at a treatment or collection facility'

OFF SITE STORAGE;

The following are the minimum requirements that should be applied to all off-site storage places. [57]

1.Bunding.

2.Security.

3.Biohazard signs.

4.Spill containment facility.

ON SITE STORAGE:

The following are the minimum requirements which should be applied to all on-site storage places. [57]

1.Proper position.

2.Accesible to collection vehicles.

3. Secure and lockable.

4 Bunded without leakage.

5 Well signposted.

6. well lighted.

Transporting inside (In the Health Facilities)

Transporting the waste for treatment should either be done in covered wheelbarrows or trolleys. It is best to avoid manual loading wherever feasible. Before transportation, the bags or containers containing the BMW should be sealed or covered by a lid. Before the bag containing the BMW is transported, it must be accompanied by a document that has been signed by a nurse or doctor and includes the date, shift, quantity, and destination. Special vehicle should be utilized by the transportation operator to limit contact of biomedical waste and the general public. The shipping containers need to be completely enclosed. The possibility of an accident should be ruled out, the truck has to be designed accordingly, and the driver needs to be instructed regarding what to do in the event of an accidental spill.[61]

WASTE TREATMENT AND DISPOSAL

Treatment of Bio-Medical Waste may require following processes:

1. Thermal processes

2. Chemical processes

3. Mechanical processes

4. Irradiation processes

5. Biological processes

1. Thermal processes

Heat is used in these processes to disinfect. Based on the temperature at which they operate thermal processes are classified into Low-heat and High-heat categories. The former one (93-177 degrees Celsius) utilizes electromagnetic radiation, steam or hot water and disinfect the waste. [57]

E.g.- Microwave and Autoclave.

1.1 Incineration

Burning in raised temperature under monitored conditions is the principle of incineration. All those waste which cannot be reused or recycled nor could be disposed off in pits are incinerated.

Characteristics of Incineration waste[57]

- In case of single chamber incinerators above 2000 kcal/kg and in case of pyrolytic double chamber more than 3500 kcal/kg of the heating volume waste is required.
- At least 60% of the waste should be amenable to burning.
- Not more than 20% of the waste should be noncombustible
- Moisture below 20%

Types of incinerators:[57]

1. Dual chamber pyrolytic incinerator, specially designed to treat the infectious waste.

2. Mono chamber incinerator with static grade furnace, to be used only when pyrolytic incinerator is not feasible.

3. Rotary type incinerator suitable for disposal for genotoxic and heat resistant chemicals.

- Incinerators must be properly manufactured to meet emission limits.
- Any chemical treatment using chlorine-based disinfectants must never be practiced.
- The prescribed limit of toxic metals producing ash must be adhered to.
- As far as fuel for the incinerator is concerned those containing less quantity of Sulphur such as diesel must be used.

One major environmental concern is about toxic emissions of Dioxins and Furans from incineration of polyvinyl chloride, the major Component of medical waste. Experiment conducted in animals have proved dioxins to be causing cancer and other mutation [63]

STANDARDS FOR INCINERATORS

The equipment should have the following operating and emission standards.[61]

Item that should not be Incinerated.

- Glass ware.
- Rubber
- Chemicals containing Acids [61]

1.2. Autoclaving

Steam is used to disinfect waste in autoclaving making it a low temperature thermal process. On the basis of removal of air pockets: gravity flow autoclaves and vacuum autoclaves are the two types. The autoclave should only be used for disinfecting and treating biomedical waste. 135ºC temperature and 31 psi pressure are required for autoclaving not less than 30min; so, the specifications of time, temperature, and pressure have to be met for effective medical waste treatment. If these were not met because of whatever reason, the waste needs to be autoclaved again, to meet the correct temperature and pressure.[57]

1.3. Microwaving

In this method, moist heat and steam produced by microwaves, are used for disinfecting the biomedical waste.

The batch type of microwave for biomedical waste is a disinfection system, designed in India. The heat treatment, which continues for 25-30 mins, makes the waste harmless and which can be disposed of as municipal waste[64].

High-heat microwaving (540-8,3000 degrees Celsius) uses burning and raised-temperature plasma to disinfect and demolish waste. Hydroclaving and incinerating are included in the high heat method.

Hydroclaving is a type of waste treatment using principle of steam that include splitting and fragmenting of the waste followed by drying. It proves to be more expensive than an autoclave, which limits its use. One microwave plant is installed in one of Bangalore's hospitals[57].

A. Operating Standards [57]

- Not less than 99.0% efficiency while combustion is allowed.
- A temperature of 800+ 50 degrees Celsius must be the maintained for Primary Chamber
- At least 1 (one) second of resistance time at 1050° + - 50° C, with a minimum of 3% oxygen in the stack gas for the secondary chamber must be maintained.

B. Emission Standards [57]

Parameters	Concentration mg/Nm3 at (12% C02 correction)
1. Particulate matter	150
2. NCI	50
3. Nitrogen Oxide	45

4. Volatile organic compounds in ash shall not be more than 0.01 %.

5. The stack should stand for a minimum of 30 metres.

2.Chemical processes

Sodium hypochlorite, hydrogen peroxide, dissolved chlorine dioxide etc. are some of the chemicals used for disinfection. Majority of the chemicals use a lot of water and necessitate the use of neutralizing agents.[57]

Formula to Calculate 1 Litter of 1% Sodium hypochlorite from available 5% Strength.

$$\frac{Weight}{Volume} = \frac{weight\ of\ solution}{\text{Strength of Solution}}\ x\ \%\ Sodium\ hypochlorite$$

$$\frac{1000}{5}\text{x1} = 200\text{ml of Sodium hypochlorite}$$

200ml of sodium hypochlorite

In 1 litter of water we have 1000ml

So 1000-200ml= 800ml of water+ 200ml of Sodium hypochlorite

3. Mechanical processes

The physicality of the waste is changed in these processes in order to make it easier to handle. Also, this could be used along with other treatment modalities. Following are the two chief processes.

Compaction - It is a process used to decrease the volume of waste that is relatively rare in India.

Shredding- Plastic and waste of paper are destroyed in by this method with the aim of restricting there re usage again. Any waste to be shredder should be prior disinfected. We have electric shedder available in our country.[57]

Land filling

It is the oldest method of waste disposal. [57]

It could be of two types:

1. Open dumping- An open dumping is define as a land disposal site at which solid wastes are disposed of in a manner that does not protect the environment and are exposed to the element, vectors and scavengers.

2. Sanitary landfill- A landfill is a facility designed for solid waste disposal into the ground. A well-engineered landfill is made to minimize adverse effects to public health.

A volumetric ratio of waste to cover of 4:1 is common, so the cover soil ends up being a good portion of material in the landfill. The overall height is typically 10-15 feet before that area of landfill is complete and new waste is placed elsewhere.

Above two are the most common used method for hospital waste disposal worldwide. Unfortunately, in developing countries like India land filling is not secured and poses hazardous to both our health and environment.[65]

In Lahore, as in other Pakistani cities, no proper measures for hospital waste management are in place. The standard practice for hospital waste disposal is to dump it in the nearest municipality provided container.[66]

In an epidemiological study, conducted by Dolk h in Europe in1998, it was observed that women living in hazardous landfill sites have more babies with congenital deformities.[67]

Deep Burial

A 2-metre-deep pit or trench is dug. In this method the waste is filled in half of the pit followed by 50cm of lime and the rest with the soil. It is critical to ensure that animals do not come in closes contact to it. Galvanized wire/ iron sheet covers are helpful to prevent it. [57]

Inertization

In this method the waste is mixed with other substance so that the toxic element does not contaminate the surrounding surface or water. A mixture containing drugs (65%), lime and cement by 15% weight each 5% of water, is a typical example.[57]

4. Irradiation processes

Wastes are exposed to UV rays or ionizing radiation are used to treat the waste in this method in controlled surroundings. The resulted waste must be shredded to make it unrecognizable.

5. Biological processes

- The biological processes include composting and anaerobic digestion.
- The composting can take place in heaps or in composting facilities with optimization of the condition of the process.
- These processes are appropriate for human organs, tissues, chemicals, and incinerator ash.
- They served dual propose of disinfecting the waste as well as destroying all organ constituents, with glass and plastics left in the residues. [68]

Disposal of Sharps:

Each year, more than 16 billion injections are administrated worldwide and in developing countries, more than 50% of injections are unsafe. [69]

Circular or rectangular pits should be made to dispose the sharp after disinfection. After construction of such pits, bricks or concrete could be used to line them. On the top of the pit should be a slab made up of concrete, through which a 20mm diameter pipe runs up to 1.5m above the slab. Once this pipe is fully exhausted, a new pipe is used.[70]

Radioactive waste from medical establishments

Radioactive bio medical waste has a low level of radioactivity when it is stored under a controlled and careful manner, which allows this radioactive medical waste to be treated as other biomedical waste. Special precaution with an expert advice should be taken when old equipment containing radioactive substance is discarded.[71]

Mercury waste management in a hospital.[72]

- Within the area of work, the radioactive waste needs to be identified and separated.
- Solid radioactive waste should be collected in foot-operated containers with disposable polythene lining, and liquid waste should be collected in polythene carboys.
- Avoid storing radioactive waste in glass containers.
- Before choosing the method of disposal, each package is watched over and labelled for the activity level.
- Segregating combustible radioactive waste from non-combustible waste is an option for some hospitals that have incinerators and authorization to burn combustible radioactive waste.
- Use different waste collection bags and bins for Tc-99m and I-131 when using two different isotopes with different half-lives.
- The name of the isotope, level of activity, and date of monitoring must be written on a label attached to each bag or bin.

Battery/ Lead waste management in a hospital.[73]

- Batteries are potentially hazardous waste because they contain heavy metals and corrosive electrolyte solutions.
- Each battery contains a corrosive sulfuric acid electrolyte solution and contains lead.
- In electronic devices used hospitals, smaller sealed lead-acid batteries are used.

- Lithium-ion batteries and devices containing these batteries should never be thrown away in any biomedical waste colour coded bins.
- Lithium/ Lead ion batteries should be recycled separately.
- Instead of being thrown away or placed in municipal recycling bins, Lithium/ Lead batteries, should be recycled at authorized battery electronics recyclers that accept batteries.
- Tape battery terminals and/or place lithium-ion batteries in separate plastic bags to prevent fires.
- If the Lithium/ Lead battery is damaged, contact the manufacturer of the battery or device for specific handling instructions.

Standard for Liquid Waste

The standard parameter of liquid waste generated from the hospitals are as follow:[57]

Parameter	**Permissible limit**
pH	6.5- 9.0
Oil and grease	10 mg/l
Suspended solids	100mg/l
COD (Chemical oxygen demand)	250 mg/l
BOD (Biochemical oxygen demand)	30 mg/l
Bioassay test	90% survival of fish after 96 hours in 100% effluent

HAZARDS OF BIOMEDICAL WASTE:

WHO reports that global life expectancy is increasing every year. However, infectious disease-related mortality is on the rise. According to a WHO study, infectious diseases kill more than 50,000 people every day. One of the factors contributing to the increase in infectious diseases is poor waste management. Most infectious like viruses, bacteria, and parasites are found in blood, body fluids, and body secretions, which are the key elements of bio-medical waste. All of the human contacts are the major source through which they become a potential source of infection. HIV and the hepatitis viruses are the major cause of infections and diseases that have been associated to biomedical waste. Other prevalent diseases spread by poor waste management include tetanus, whooping cough, tuberculosis, pneumonia, diarrheal illnesses, and others.[68]

Occupational health hazards:

Improper waste management can affect:

- Those who come in contact with the facility include the laundry staff, nurses, emergency medical technicians, and refuse workers.
- For all who handle waste, scavenge, and for the general public outside the hospital
- Health care workers are at risk for health problems due to injuries from Sharps objects as well as exposure to radioactive waste and hazardous chemicals managed by waste handlers at all levels.[74]

Hazards to the public:

Biomedical waste can also negatively impact the general public's health by following reason.

- Disease spread is aided by improper behavior patterns, such as the disposal of biomedical waste in public dustbins, open areas, and water sources.
- Emissions from open burning and incinerators expose people to risky gases that can lead to cancer and lung disorders.

- Radioactive waste can also pose serious health risks to health care worker.
- Healthcare activities carried in home setup also create biomedical waste, which are frequently being ignored.
- Bio-medical waste is produced by an increase in the number of diabetic's patients who self-inject insulin, terminally ill patients treated at home by private nurse, and other activities of a similar nature that can be a hazardous to human health.[75]

Health hazards to animals and birds by Bio-medical waste

- Animals that scavenge on open dumps can be choked by plastic waste.
- Sharps injuries are common in animals.
- Animal and bird health may be at risk from harmful chemicals like dioxins and furans.
- Even an animal's reproductive system can be harmed by heavy metals. Changes were observed in microbial ecology as well as the spread of antibiotic resistance are seen in animals. [75]

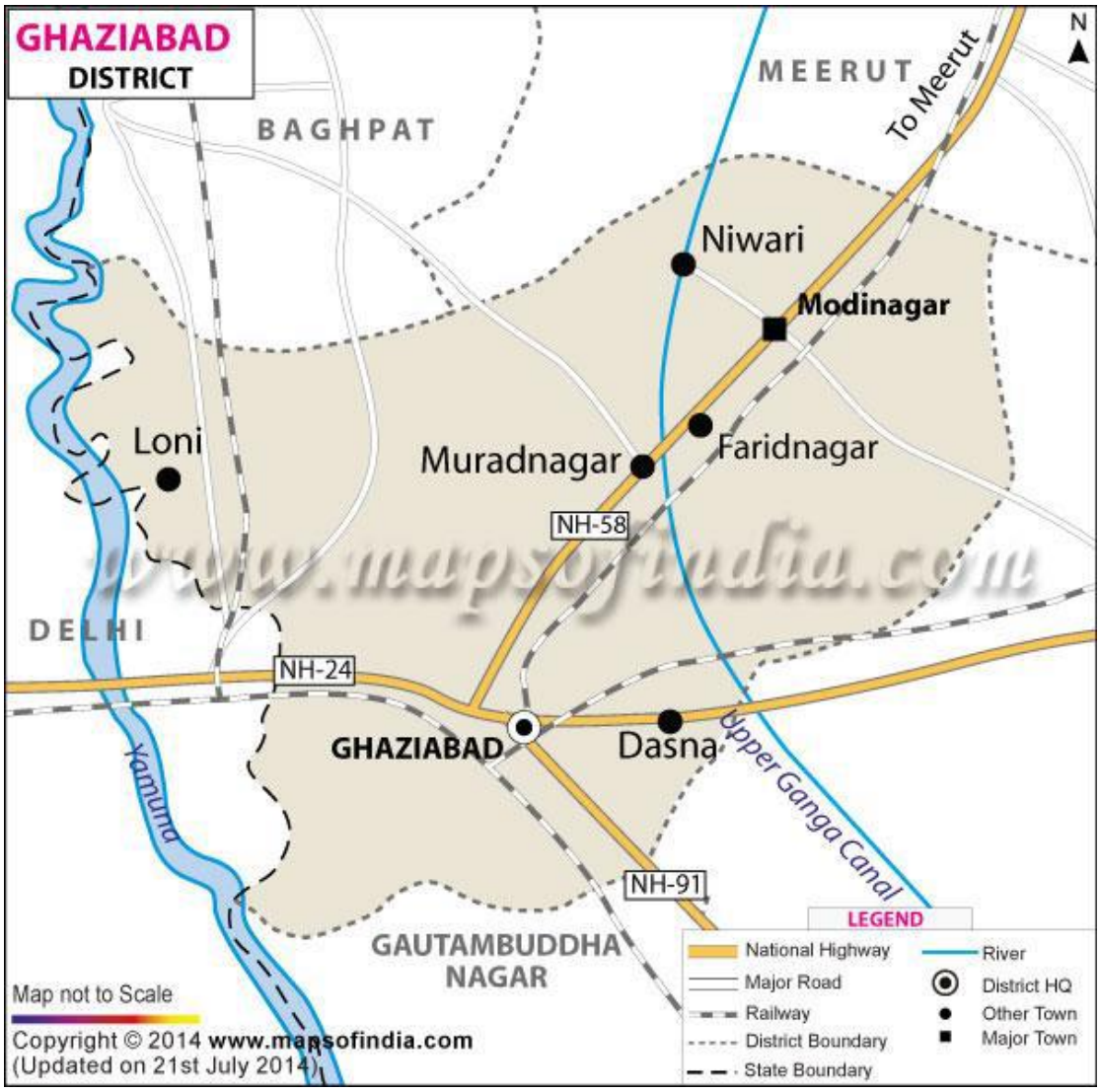
Material and Methods

MATERIAL AND METHODS

Location

The present study entitled **"A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad"** was conducted in the district of Ghaziabad. It is situated in the middle of Ganga-Yamuna Doab in the north-western part of Uttar Pradesh. River Hindon divides the district into cis-Hindon area and trans-Hindon area.[76] Ghaziabad city is bounded by Meerut and Bhaghpat in the north, Bulandshahar and GautamBuddh Nagar in the south, Hapur in the east and Yamuna river in the west. It also adjoins Haryana and the national capital, Delhi. Thus, acting as the gateway of Uttar Pradesh.[77]

The total area of district Ghaziabad is 1,034 Sq. Km. The total population of Ghaziabad district is 33.43 lakhs out of which 27.52 lakhs is urban and 5.91 lakhs is rural population. [78] It is divided into five administrative zones City Zone, Kavi Nagar, Mohan Nagar, Vijay Nagar and Vasundhara. In rural area it is divided into four blocks, Muradnagar, Dasna, Loni and Modinagar [76]



*Maps of India. Ghaziabad district map. [Internet] 2014. [cited 1 Dec2021]. Available from:https:// www.mapsofindia.com/ maps/ uttarpradesh/ districts/ ghaziabad.htm.

Organization of Study

The present study is entitled "To assess Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad" organized at Santosh Medical College, Ghaziabad.

Study Setting.

The study was carried out in

- Selected government health facilities in district Ghaziabad.
- Department of Community Medicine, Santosh Medical College, Ghaziabad

Study Design

This a health centre based cross-sectional study, undertaken to assess the knowledge and practice regarding Bio-Medical waste and its associated factors in district Ghaziabad.

Sampling Frame

Government health facilities in district Ghaziabad i.e. Community health centre (C.H.C), Primary health centre (P.H.C) and Sub-centres

Study Population: Health care worker employed in the selected government health care facilities.

Study Unit: Doctor, Nursing Staff, Laboratory technician and Sanitary staff working in the Health care facilities such as community health centre and Primary Health Centre will be selected for the study. At the Sub-Centre level Auxiliary nurse midwife (ANM) was selected.

Sample Size

Information regarding the total number of health care staff working in the district was collected from the CMO office. Health care workers included doctors, nurses, laboratory technician and sanitary staff. It was found that the total health care workers were 232.

The sample size of the present study was calculated by using the estimated prevalence of precise knowledge (79%) on BMW among healthcare workers, reported by Pavan P. Amin et al, Surendra Nagar, Gujarat, India in 2018.[79] Using the proportion with the

estimated population of health care worker i.e., 232 (which is the finite population) we have calculated the sample size using formula

$$n = \frac{m}{1 + \frac{m-1}{n}}$$

Where $m = \frac{z^2_{1-\alpha/2}pq}{d^2}$

$$m = \frac{[1.96\ x\ 1.96\ x\ 0.79\ x\ 0.21]}{0.05x0.05} = 254.8$$

i.e. m= 255

$$n = \frac{255}{1 + \frac{255-1}{232}} = 122$$

n= sample size

m= Adjustment factor with respect to FPC (finite population correction)

$z^2_{1-\alpha/2}$= Critical value of z for 95% confidence interval

p= Estimated proportion

q= 1-p

d= Desired absolute precision

The required sample size came out to be 122. Proportional allocation scheme was used to select the required number of health care workers from each facility.

Criteria for Selecting the sample

The sample selection was based on the following inclusion and exclusion criteria:

Inclusion criteria:

- All the medical and paramedical workers who were on duty during visit and gave consent.

Exclusion Criteria

- Any Trainees posted for short period of time in the facility.
- Those who did not give consent

Sample Technique

The total sample size was first stratified on the basis of educational qualification of the respondents and then on the basis of health care facilities where the respondents were posted.

At both these stages stratified sampling technique was used with proportional allocation scheme. There are four blocks in district Ghaziabad, in each block there is one CHC, under each CHC there are four PHC. The total number of sub-centres in these four blocks are 145. Data was collected randomly from 4 CHC, 12 PHC and 50 Sub-centres.

Stage 1: Information regarding the health care staff posted at different centers was collected from the CMO office.

Stage 2: On the basis of proportionality sampling, the number of health care staff to be interviewed was selected from different health care facilities.

Twenty-seven doctors were selected, of which 18 were posted in CHC and 9 were posted in PHC. Similarly, 75 nurses were selected, 4 from CHC, 21 from PHC and 50 from sub centres respectively. We selected 6 lab. technicians, one from CHC and 5 from PHC. Lastly, 14 sanitary staff were selected, 3 from CHC and 11 from PHC. Table 1 shows proportional sampling of healthcare staff posted in different health care facilities.

Total sample size	**Health care worker**	**Health Facilities**
N=122	Doctor (27)	CHC-18
		PHC-9
	Nurse (75)	CHC-4
		PHC-21
		Sub-Centre-50
	Lab Technician (06)	CHC-1
		PHC-5
	Sanitary Staff (14)	CHC-3
		PHC-11

Table: Shows total number of health care worker in different health facilities

Health care workers were selected randomly from their respective health care facilities on the basis of proportionality sampling with the help of random number table.1

Period of Study

The data was collected from November 2021 to April 2022. A pilot study was carried out in early among 10 HCWs to test the study tool. The reliability of the questionnaire was tested (r = 0.935) using Cronbach's alpha and based on it the interview schedule was modified.

Data Collection

Approval from the medical ethics committee of Santosh Medical College was taken prior to starting the survey.

All respondents were briefed about the objectives of this study and consent to participate was taken from all the study participants (Annexure-III). Confidentiality of information was assured to the respondents. It took 15-20 minutes to interview a single respondent.

A total of 122 health care workers were interviewed. Their responses were elicited by asking questions both in Hindi and English.

The investigator was accompanied by a social worker, from the Department of Community Medicine, Santosh Medical College, Ghaziabad.

Tools of Data Collection

A semi-structured questionnaire for in-depth interview of the study population along with an observational checklist of BMW management guidelines[80]was used as the tool for data collection. (Annexure-IV)

The questionnaire had four sections: the first section consisted of socio-demographic information; the second section had knowledge related questions about bio-medical waste, the third section was an observational questionnaire assessing the practice of healthcare professionals (HCPs) and the fourth part of the questionnaire consisted of questions regarding associated factors with respect to COVID-19 and BMW management.

The first section of the questionnaire collected information related to socio-demographic variables of the study participants including:

1. Health Facilities (CHC/PHC/Sub-centre),
2. Name of the health care worker.
3. Age (taken in years and clubbed into five groups; 18- 30, 31-40, 41-50, 51-60 and 61 and above),
4. Gender (male, female, others)
5. Education of the respondent (divided into five categories depending on the education status of the participants as 10^{th} pass, 12^{th} pass, diploma, graduate and post graduate).
6. Occupation (Doctor, Nurse, Lab technician and Sanitary staff)

The second section was related to knowledge regarding bio medical waste management. This tool consisted of 23 multiple choice questions, each of which had one correct answer. It was divided into four subgroups for the purpose of better analysis and scoring.

The first subgroup had seven questions, i.e. question related to general knowledge regarding BMWM (K1, K5, K13, K15, K17, K18, K19) (each given a score of 1 for correct answer and 0 for incorrect response). Total score ranged from 1-7.

Second subgroup was about knowledge related to precautionary measures regarding BMWM (K9, K10, K11, K16, K22) (each given a score of 1 for correct answer and 0 for incorrect response) Total score ranged from 1-4

Third subgroup was related to knowledge handling rules regarding BMWM (K2, K3, K4, K6, K14, K23 (each given a score of 1 for correct answer and 0 for incorrect response) Total score ranged from 0-6.

Fourth subgroup was related to knowledge regarding bio-hazards (K7, K8, K12, K120, K21) (each given a score of 1 for correct response and 0 for incorrect response). Total score ranged from 0-5.

Total Knowledge score ranged from 2-19. Median of the knowledge score was calculated and set as the cut off for categorising the study participants as having good and poor knowledge regarding BMWM.

The third section of the questionnaire consisted of questions regarding the practices of the health care staff in relation to BMWM. These questions were observation based and was used to assess the practice. It contained 21 multiple choice questions, each ofwhich had one correct answer. This section was also divided into four subgroups.

First subgroup included questions related to general practice regarding BMWM. (P1, P4, P6, P8, P11, P12, P19). It included seven questions Then each question was given a score of 1 for correct response and 0 for incorrect response depending on the question). Total score ranged from 0-7.

Second subgroup consisted of questions related to handling rule practices (P2, P3, P5, P17, P20) It included five questions. (Each question was given a score of 1 for correct response and 0 for incorrect response). Total score ranged from 0-5.

Third subgroup was related to Practice against bio-hazards (P7, P18). It consisted of two questions (each given a score of 1 for correct answer and 0 for incorrect response) Total score ranged from 0-2.

Fourth subgroup was related to practice regarding precautionary measures (P9, P10, P13, P14, P15, P16, P21) It comprised of seven question (each given a score of 1 for correct answer and 0 for incorrect response) Total score ranged from 0-6.

Practice of HCWs was observed and the questionnaire was filled. Total Practice score ranged from 0-19. Median of the practice score was calculated and set as the cut off for categorising the study participants as having good or poor practice regarding BMWM.

The fourth section of the questionnaire consisted of questions regarding associated factors with respect to COVID19 questionnaire. It contained 15 multiple choice questions, each of which had one correct response. It was also divided into two subgroups.

First subgroup included questions related to knowledge with respect to COVID-19 and biomedical waste management (A1, A2, A3, A4, A5, A6, A7, A8, A9). It included nine questions, each question was given a score of 1 for correct response and 0 for incorrect response depending on the question). Total score ranged from 0-9.

Second subgroup included questions related to practice with respect to COVID-19 and biomedical waste management (A10, A11, A12, A13, A14, A15, A16). It included six questions, each question was given a score of 1 for correct response and 0 for incorrect response depending on the question). Total score ranged from 0-6.

Total associated factors with respect to COVID19 questions were filled. Total associated score ranged from 0-13. Median of the associated score was calculated and set as the cut off for categorising the study participants as having good or poor practice regarding BMWM.

Data Management and Statistical Analysis

The data was collected and entered in MS Excel 2020 (version 16). Statistical analysis was performed using SPSS software (trial version 16). Descriptive statistics like frequencies, percentages, mean and standard deviations were applied for qualitative and categorical variables. Chi-Square test was used to find the association between categorical variables with p-value <0.05 taken to be statistically significant and p-value>0.05 taken as statistically insignificant. Regression analysis was also performed with 95% confidence interval to determine significant associations between dependent and independent categorical variables.

Observations

OBSERVATIONS

The study entitled "A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad" was conducted in health care facilities of rural area of Ghaziabad city. Following findings are found in 122 health care workers selected in the study.

Table 1: Health care facilities wise distribution (n=122)

Health Facilities	**Health care worker (n=122)**	**Percentage (%)**
CHC (Community Health Center) (n=4)	26	21.3
PHC (Primary Health Center) (n=12)	46	37.7
Sub-Center (n=50)	50	41
Total	122	100

Table 1: Show out of total health care worker 26 (21.3%) were from CHC, 46 (37.7%) were from PHC and 50 (41%) were from sub-centre.

Table 2: Distribution of study participants according to occupation.

Health Facilities	**Occupation**				
	Doctor (%)	**Lab Technician (%)**	**Nurse (%)**	**Sanitary Staff (%)**	**Total (100%)**
CHC (Community Health Centre)	18 (69.2)	1 (3.8)	4 (15.4)	3 (11.5)	26
PHC (Primary Health Centre)	9 (19.6)	5 (10.9)	21 (45.7)	11 (23.9)	46
Sub-Centre	0 (0)	0 (0)	50 (100)	0 (0)	50
Total	27 (22.1)	6 (4.9)	75 (61.5)	14 (11.5)	122

Table 2: Of the total 27 (22.1%) doctors 18 (69.2%) were from CHC and 9 (19.6%) were from PHC. The 75 nurses selected were 50 (100%) from sub centre, 21 (45.7%) from PHC and 4 (15.4%) from CHC. One lab technician (3.8%) was from CHC and the remaining 5 (10.9%) from PHC. Regarding the 14 (11.5%) sanitary staff 11 (23.9) were from PHC and 3(11.5%) from CHC.

Figure 1: Distribution of the study participant according to Age

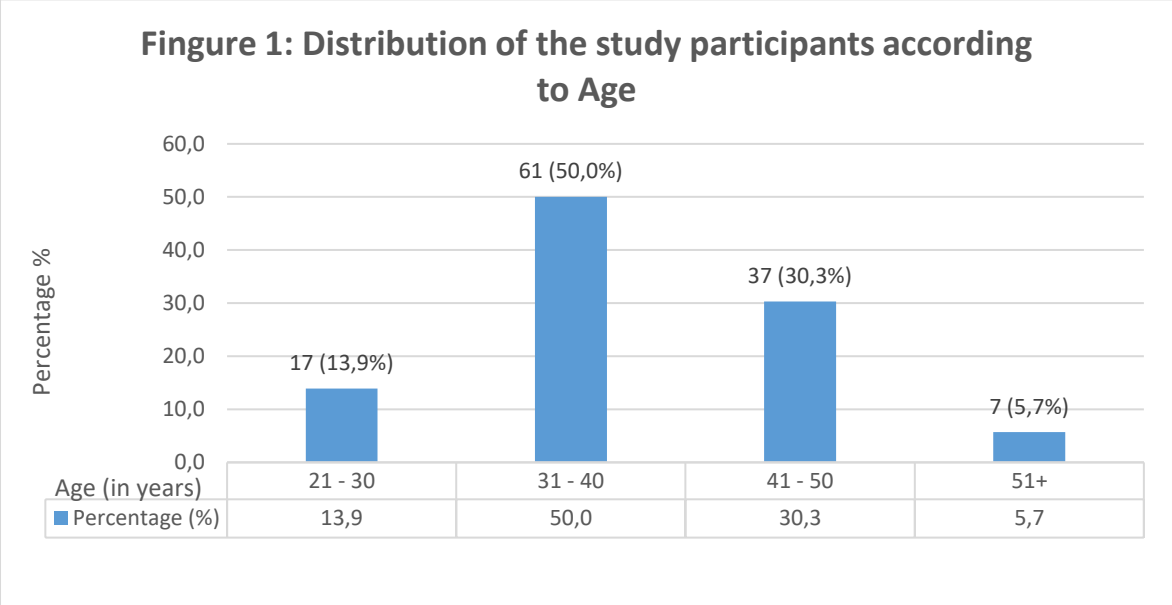


Figure 1: Maximum number of the study participants 61 (50.0%) were in the age group of 31-40 years, followed by 41-50 years' age bracket having 37 (30.3%). There were 17 (13.9%) subject of the age 21-30 years and 7 (5.7%) in the age group of 51 and above years respectively.

Figure2: Gender wise distribution of the study participants (n=122)

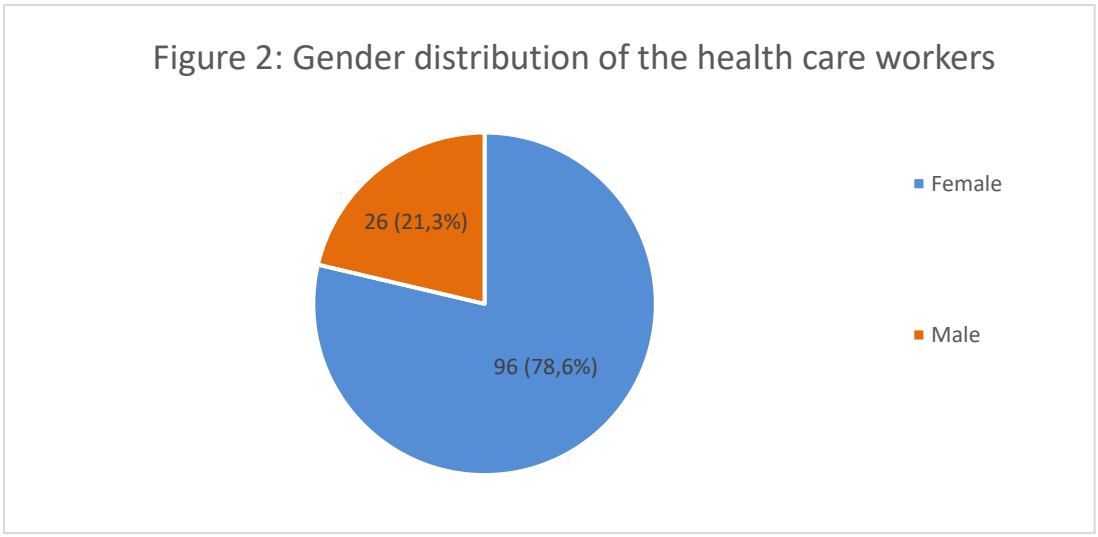


Figure2: Show that majority of the study participants 96 (78.6) were female and 26 (21.3%) were male

Figure 3: Distribution of education status of the health care workers.

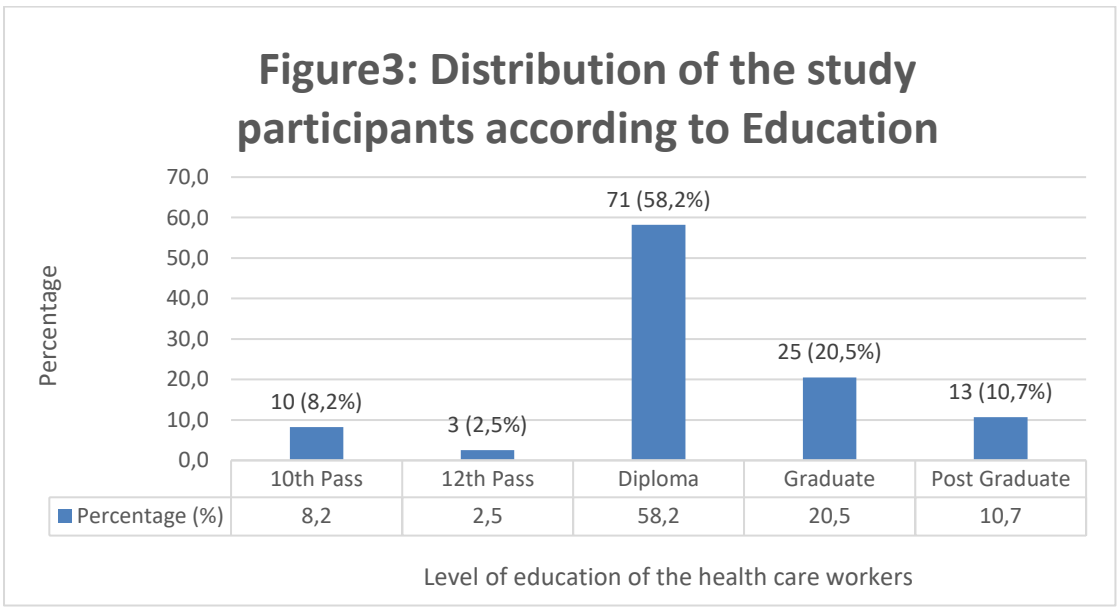


Figure 3: shows the education status of the respondents. Most of the health care workers were 71 (58.2%) diploma holders followed by 25 (20.5%) being graduate and 13 (10.7%) were post graduate. Also 10 (8.2%) had studied till 10^{th} and 3 (2.5%) up to 12^{th} respectively.

Table 3: Distribution of the health care workers according to the knowledge regarding Bio-Medical Waste Management.

Knowledge related to BMWM	Doctor (%)	Lab Technician (%)	Nurse (%)	Sanitary Staff (%)	Total (%)
K1. Are you aware of Biomedical waste management?					
Yes	27 (100)	6 (100)	71 (94.7)	7 (50)	111 (91.0)
No	0 (0)	0 (100)	4 (5.3)	7 (50)	11 (9.0)
Total	27 (100)	6 (100)	75 (100)	14 (100)	122 (100)
K2. Are you aware of Hospital Waste Management & Handling Rule?					
Yes	27 (100)	6 (100)	69 (92.0)	7 (50)	109 (89.3)
No	0(0)	0(0)	6 (8.0)	7 (50)	13 (10.7)
Total	27 (100)	6 (100)	75 (100)	14 (100)	122 (100)

Table 3: shows 111(91.0%) of the health care workers were aware of the term Biomedical waste management and 11 (9.0%) were unaware of biomedical waste management. Also 109 (89.3%) of the health care workers were aware of Biomedical waste management & handling rule and 13 (10.7%) were unaware of handling rule.

Table 4: Distribution of study participants according to the knowledge related to Biomedical waste management rule first proposed.

Occupation	**K3. Do you know when Biomedical waste (Management & Handling) Rules were first proposed?**				
	1997 (%)	1998(%)	1999(%)	2000(%)	Total (100%)
Doctor	4 (14.8)	14 (51.9)	3 (11.1)	6 (22.2)	27
Lab Technician	0 (0)	4 (66.7)	1 (16.7)	1 (16.7)	6
Nurse	15 (20.0)	22 (29.3)	3 (4.0)	35 (46.7)	75
Sanitary Staff	3 (21.4)	2 (14.3)	0 (0)	9 (64.3)	14
Total	22 (18.0)	42 (34.4)	7 (5.7)	51 (41.8)	122

Table 4: shows that half of the doctors 14 (51.9%), two third of the lab technicians 4 (66.7%), about one fourth of the nurses 22 (29.3%) and only 2 (14.3%) of the sanitary staff knew correctly that the bio medical waste management and handling rules were first proposed in 1998.

Figure 4: Distribution of the health care workers according to the knowledge regarding revised Bio-Medical Waste Management rules.

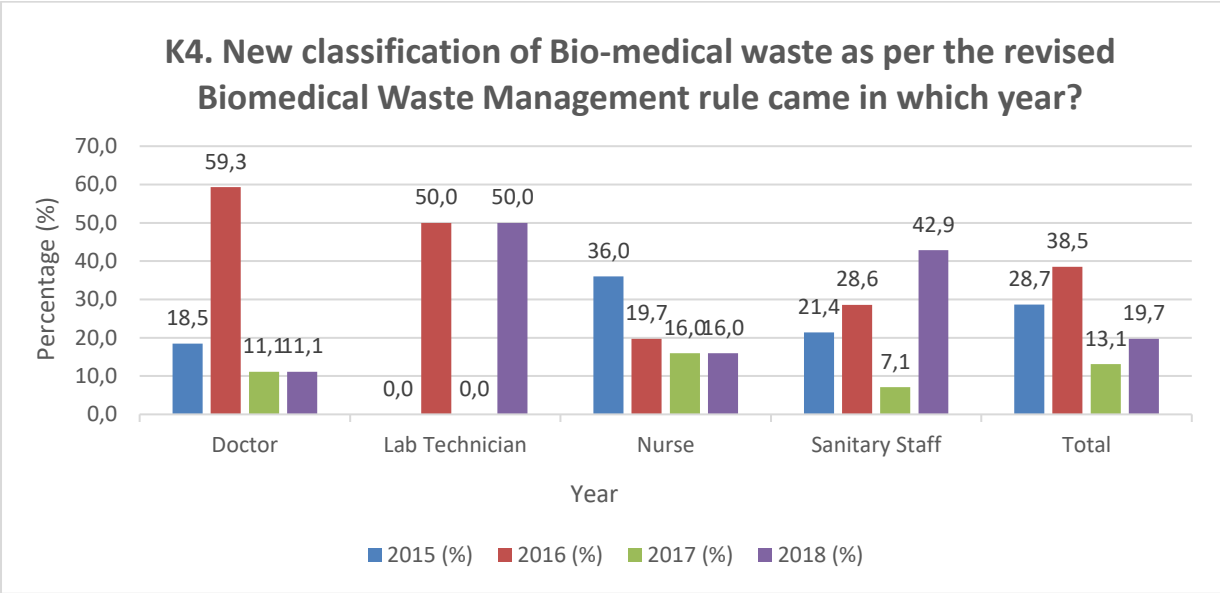


Table 5: Distribution of the health care workers according to the knowledge regarding revised Bio-Medical Waste Management rules.

Occupation	**K4. New classification of Bio-medical waste as per the revised Biomedical Waste Management rule came in which year?**				
	2015 (%)	2016 (%)	2017 (%)	2018 (%)	Total(100%)
Doctor	5 (18.5)	16 (59.3)	3 (11.1)	3 (11.1)	27
Lab Technician	0 (0)	3 (50)	0 (0)	3 (50)	6
Nurse	27 (36.0)	24 (19.7)	12 (16.0)	12 (16.0)	75
Sanitary Staff	3 (21.4)	4 (28.6)	1 (7.1)	6 (42.9)	14
Total	35 (28.7)	47 (38.5)	16 (13.1)	24 (19.7)	122

Table 5: shows that 16 (59.3%) doctors, half of the lab technicians 3 (50%), almost one fifth of the nurses 24 (19.7%) and about one fourth 4 (28.6%) of the sanitary staff knew correctly that the Bio medical waste management and handling rules were revised in 2016.

Picture 1: Storage facility according to colour coding in Community Health Centre, Dasna.

Table 6: Distribution of the health care workers according to the knowledge regarding different colour coding for the Bio-Medical Waste Management rules 2016.

Occupation	**K5. Do you know the different colour coding for the biomedical waste as per Biomedical waste management Rule 2016?**		
	Yes (%)	No (%)	Total (100%)
Doctor	26 (96.3)	1 (3.7)	27
Lab Technician	5 (83.3)	1 (16.7)	6
Nurse	73 (97.3)	2 (2.7)	75
Sanitary Staff	14 (100)	0 (0)	14
Total	118 (96.7)	4 (3.3%)	122

Table 6: shows that all of the sanitary staff 14 (100%) knew the different colour codding of the Biomedical waste, while 26 (96.3%) of the doctors, 5 (83.3%) of the lab technicians and 73 (97.3%) of the nurses were aware about the same.

Table 7: Table: Distribution of the health care workers according to the knowledge regarding agency regulating Bio-Medical Waste.

Occupation	**K6. Do you know about the agency that regulate Biomedical waste at your health care facilities?**				
	State (%)	Private (%)	No regulation (%)	Don't know (%)	Total (100%)
Doctor	18 (66.7)	7 (25.9)	0 (0)	2 (7.4)	27
Lab Technician	6 (100)	0(0)	0(0)	0(0)	6
Nurse	46 (61.3)	17 (22.7)	4 (5.3)	8 (10.7)	75
Sanitary Staff	3 (21.4)	4 (28.6)	1 (7.1)	6 (42.9)	14
Total	73 (59.8)	28 (23.0)	5 (4.1)	16 (13.1)	122

Table 7: Shows all of the 6 (100%) lab technicians but only 18 (66.7%) of the doctors, 46 (61.3%) and 3 (21.4%) of the sanitary staff knew that Biomedical waste are regulated by state.

Table 8: Distribution of the health care workers according to the awareness regarding Bio-Medical hazards.

Occupation	**K7. Are you aware of biomedical waste hazards?**		
	Yes (%)	No(%)	Total (100%)
Doctor	27 (100)	0 (0)	27
Lab Technician	6 (100)	0 (0)	6
Nurse	71 (94.7)	4 (5.3)	75
Sanitary Staff	11 (78.6)	3 (21.4)	14
Total	115 (94.3)	7 (5.7)	122

Table 8: shows a total of 115 (94.3%) of the health care workers were aware of biomedical waste hazards which comprised of all of the doctors 27 (100%) and lab technicians 6 (100%), 71 (94.7%) of the nurses and 11 (78.6%) of the sanitary staff.

Table 9: Distribution of the health care workers according to the knowledge regarding diseases caused by Bio-Medical Waste.

Occupation	**K8. If yes, What are the diseases that can be cause by biomedical waste if not disposed safely?**				
	Hepatitis-B (%)	HIV/ AIDS (%)	Both (%)	None of above (%)	Total (100%)
Doctor	0 (0)	1 (3.7)	26 (96.3)	0 (0)	27
Lab Technician	0 (0)	0 (0)	6 (100)	0 (0)	6
Nurse	2 (2.7)	6 (8.0)	64 (85.3)	3 (4.0)	75
Sanitary Staff	2 (14.3)	4 (28.6)	6 (42.9)	2 (14.3)	14
Total	4 (3.3)	11 (9.0)	102 (83.6)	5 (4.1)	122

Table 9: Both Hepatitis and HIV/AIDS can be caused by Bio medical waste if not disposed safely said 6 (100%) of the lab technician, 26 (96.3%) of the doctors, 64 (85.3%) of nurses and 6 (42.9%) of the sanitary staff.

Table 10: Distribution of the health care workers according to the awareness regarding precautionary measure while handling Bio-Medical Waste.

Occupation	**K9. Are you aware of precaution to be taken while biomedical waste handling?**		
	Yes (%)	No (%)	Total (100%)
Doctor	27 (100)	0 (0)	27
Lab Technician	6 (100)	0 (0)	6
Nurse	75 (100)	0 (0)	75
Sanitary Staff	13 (92.9)	1 (7.1)	14
Total	121 (99.2)	1 (0.8)	122

Table 10: shows that all of the doctors 27 (100%), Lab technicians 6 (100%) and Nurses 75 (100%) while 13 (92.9%) of the sanitary staff were aware of the precautionary measure to be taken while handling biomedical waste.

Table 11 Distribution of the health care workers according to the awareness regarding what precautionary measure one should take, while handling Bio-Medical Waste.

Occupation	**K10 If yes, What precaution do you think one should be taking.?**			
	Gloves (%)	Mask (%)	Goggle (%)	PPE (Personal protective equipment) (%)
Doctor	26 (96.3)	24 (88.9)	22 (81.5)	22 (81.5)
Lab Technician	6 (100)	6 (100)	6 (100)	6 (100)
Nurse	75 (100)	69 (92.0)	54 (72.0)	63 (84.0)
Sanitary Staff	14 (100)	9 (64.3)	5 (35.7)	5 (35.7)
Total	121 (99.2)	108 (88.5)	87 (71.3)	96 (78.7)

Table 11: Show that among the doctors 26 (96.3%), 24 (88.9%), 22 (81.5%) and 22 (81.5%) respectively know that gloves, mask, goggle and PPE are the precaution to be taken while handling biomedical waste.

In case of sanitary staff workers, the result was 14(100%), 9 (64.3%), 5 (35.7%) and 5 (35.7%), while in case of nurses it was 75 (100%), 59 (92%), 54 (72%) and 63 (84%) for gloves, mask, goggles and PPE respectively.

Notably all of the 6 (100%) lab technicians have correctly answered that each of the four – gloves, mask, goggles and PPE should be taken as the precautionary measures.

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Table 12: Distribution of the health care workers according to the knowledge of using of PPE during Bio medical waste management.

Occupation	**K11. Do you think, wearing a PPE can reduce risk of infection?**		
	Yes (%)	No (%)	Total (100%)
Doctor	27 (100)	0 (0)	27
Lab Technician	6 (100)	0 (0)	6
Nurse	75 (100)	0 (0)	75
Sanitary Staff	12 (85.7)	2 (14.3)	14
Total	120 (98.4)	2 (1.6)	122

Table 12: shows that all the doctors 27 (100%), lab technicians 6 (100%) and Nurses 75 (100%), 12 (85.7%) sanitary staff think that wearing a PPE can reduce the risk of infection.

Table 13: Distribution of the health care workers according to the knowledge regarding reporting of hazardous event in handling of Bio medical waste.

Occupation	**K12. As per the Bio Medical Waste Management Rules, 2016, any hazardous event should be reported/forwarded within?**				
	12 hour (%)	24 hour (%)	48 hour (%)	72 hour (%)	Total (100%)
Doctor	11 (40.7)	13 (48.1)	1 (3.7)	2 (7.4)	27
Lab Technician	4 (66.7)	2 (33.3)	0 (0)	0 (0)	6
Nurse	48 (64.0)	22 (29.3)	3 (4.0)	2 (2.7)	75
Sanitary Staff	9 (64.3)	3 (21.4)	0 (0)	2 (14.3)	14
Total	72 (59.0)	40 (32.8)	4 (3.3)	6 (4.9)	122

Table 13: Shows any hazardous event occurred while handling biomedical waste should be reported in 24 hours is known by 13 (48.1%) doctors, 2 (33.3%) lab technicians, 22 (29.3%) nurses and 3 (21.4%) sanitary staff worker.

Table 14: Distribution of the health care workers according to the knowledge regarding thickness of plastic sheet provided inside different bins.

Occupation	**K13. What should be the thickness of a plastic sheets provided inside the different bins?**				
	25mm (%)	50mm (%)	70mm (%)	75mm (%)	Total (100%)
Doctor	7 (25.9)	13 (48.1)	2 (7.4)	5 (18.5)	27
Lab Technician	2 (33.3)	4 (66.7)	0 (0)	0 (0)	6
Nurse	21 (28.0)	20 (26.7)	15 (20.0)	19 (25.3)	75
Sanitary Staff	9 (64.3)	3 (21.4)	1 (7.1)	1 (7.1)	14
Total	39 (32.0)	40 (32.8)	18 (14.8)	25 (20.5)	122

Table 14: Shows doctor 13 (48.1%) have most and sanitary staff 3 (21.4%) have the least knowledge of correct thickness of plastic sheet provided inside different bins. Among the lab technicians, 4 (66.7%) and 20 (26.7%) of nurses knew that 50mm is the correct thickness of the plastic sheets.

Table 15: Knowledge of health care workers regarding maximum time for storage of Bio medical waste.

Occupation	**K14. According to biomedical waste (Management & Handling) Rule, waste should not be stored beyond?**				
	12 hour (%)	24 hour (%)	48 hour (%)	72 hour (%)	Total (100%)
Doctor	8 (29.6)	15 (55.6)	3 (11.1)	1(3.7)	27
Lab Technician	1 (16.7)	3 (50.3)	2 (33.3)	0 (0)	6
Nurse	29 (38.7)	40 (53.3)	2 (2.7)	4 (5.3)	75
Sanitary Staff	4 (28.6)	9 (64.3)	0 (0)	1 (7.1)	14
Total	42 (34.4)	67 (54.9)	7 (5.7)	6 (4.9)	122

Table 15: shows that a meagre 7 (5.7%) the study participants correctly knew that the bio medical waste should not be stored beyond 48 hours, while 42(34.4%), 67 (54.9%) and 6 (4.9%) said it to be 12 hours, 24 hours and 72 hours respectively.

Table 16: Distribution of the health care workers according to the knowledge regarding correct colour categories of pre-treated vacutainer.

Occupation	**K15. Pre-treated vacutainers/vials containing blood samples are handed over to agency in which colour category waste?**				
	Black (%)	Blue (%)	Red (%)	Yellow (%)	Total (100%)
Doctor	1 (3.7)	10 (37.0)	10 (37.0)	6 (22.2)	27
Lab Technician	0 (0)	1 (16.7)	4 (66.7)	1 (16.7)	6
Nurse	4 (5.3)	19 (25.3)	36 (48.0)	16 (21.3)	75
Sanitary Staff	0 (0)	4 (28.6)	9 (64.3)	1 (7.1)	14
Total	5 (4.1)	34 (27.9)	59 (48.4)	24 (19.7)	122

Table 16: shows that out of total 122 health care workers nearly half 59 (48.4%) knew that pre-treated vacutainer was handed over in Red category waste whereas 5 (4.1%), 34 (27.9%) and 24 (19.7%) said the colour category to be Black, Blue, and Yellow respectively.

Further 10 (37.0%) of the doctors 4 (66.7%) of the lab technician, 9 (64.3%) of the sanitary staff and 36 (48.0%) of nurses correctly answered the colour category.

Table 17: Distribution of the health care workers according to the knowledge regarding general waste collection.

Occupation	**K16. Is general waste collected in yellow bin?**		
	Yes (%)	No (%)	Total (100%)
Doctor	8 (29.6)	19 (70.4)	27
Lab Technician	1 (16.7)	5 (83.3)	6
Nurse	17 (22.7)	58 (77.3)	75
Sanitary Staff	2 (14.3)	12 (85.7)	14
Total	28 (23.0)	94 (77.0)	122

Table 17: Shows that more than three fourth of health care workers 94 (77%) knew that the general waste should not be collected in yellow colour coded bins. Among those who didn't know 8 (29.6%) were doctors 1 was (16.7%) lab technician, 17 (22.7%) were nurses and 2 (14.3%) were sanitary staff workers.

Table 18: Distribution of the health care workers according to the knowledge regarding the most important aspect of Biomedical waste management.

Occupation	**K17. Most important aspect of Bio Medical Waste management is?**				
	Collection (%)	Segregation (%)	Storage (%)	Transportation (%)	Total (100%)
Doctor	3 (11.1)	22 (81.5)	1 (3.7)	1 (3.7)	27
Lab Technician	0 (0)	5 (83.3)	0 (0)	1 (16.7)	6
Nurse	8 (10.7)	56 (74.7)	3 (4.0)	8 (10.7)	75
Sanitary Staff	3 (21.4)	11 (78.6)	0 (0)	0 (0)	14
Total	14 (11.5)	94 (77.0)	4 (3.3)	10 (8.2)	122

Table 18: Shows that 22 (81.5%) of the doctors 5 (83.3%) of lab technician, 56 (74.7%) of the nurses and 11 (78.6%) of the sanitary staff workers, correctly said that segregation is most important aspect of biomedical waste management.

Table 19: Distribution of the health care workers according to the knowledge regarding treatment of infectious waste collected in yellow bag.

Occupation	**K18. How should the infectious waste collected in yellow bag be treated?**				
	Deep Burial (%)	Incinerator (%)	Microwaving (%)	Land Fill (%)	Total (100%)
Doctor	7 (25.9)	17 (63.0)	0 (0)	3 (11.1)	27
Lab Technician	0 (0)	6 (100)	0 (0)	0 (0)	6
Nurse	42 (56.0)	26 (34.7)	0 (0)	7 (9.3)	75
Sanitary Staff	10 (71.4)	2 (14.3)	0 (0)	2 (14.3)	14
Total	59 (48.4)	51 (41.8)	0 (0)	12 (9.8)	122

Table 19: shows that of the total 51 (41.8%) health care workers who knew that incineration is the treatment for yellow bags, 17 (63.0%) were doctors, 6 (100%) were lab technicians, 26 (34.7%) were nurses and 2 (14.3%) were sanitary staff workers.

Table 20: Distribution of the health care workers according to the knowledge regarding pre-treatment of waste before disposal.

Occupation	**K19. What are the highly infectious waste that are pre-treated onsite before sending for final treatment or disposal?**				
	Anatomical waste (%)	Expired Medicine (%)	Laboratory waste (%)	Metallic Body Implant (%)	Total (100%)
Doctor	9 (33.3)	0 (0)	18 (66.7)	0 (0)	27
Lab Technician	2 (33.3)	0 (0)	4 (66.7)	0 (0)	6
Nurse	39 (52.0)	5 (6.7)	30 (40)	1 (1.3)	75
Sanitary staff	12 (85.7)	0 (0)	1 (7.1)	1 (7.1)	14
Total	62 (50.8)	5 (4.1)	53 (43.4)	2 (1.6)	122

Table 20: shows that laboratory waste is pre-treated on site before sending for final disposal was correctly answered by 18 (66.7%) doctors, 4 (66.7%) lab technicians, 30 (40%) nurses and 1 (7.1%) sanitary staff.

Figure 5: Distribution of the health care workers according to the knowledge regarding biohazard symbol.

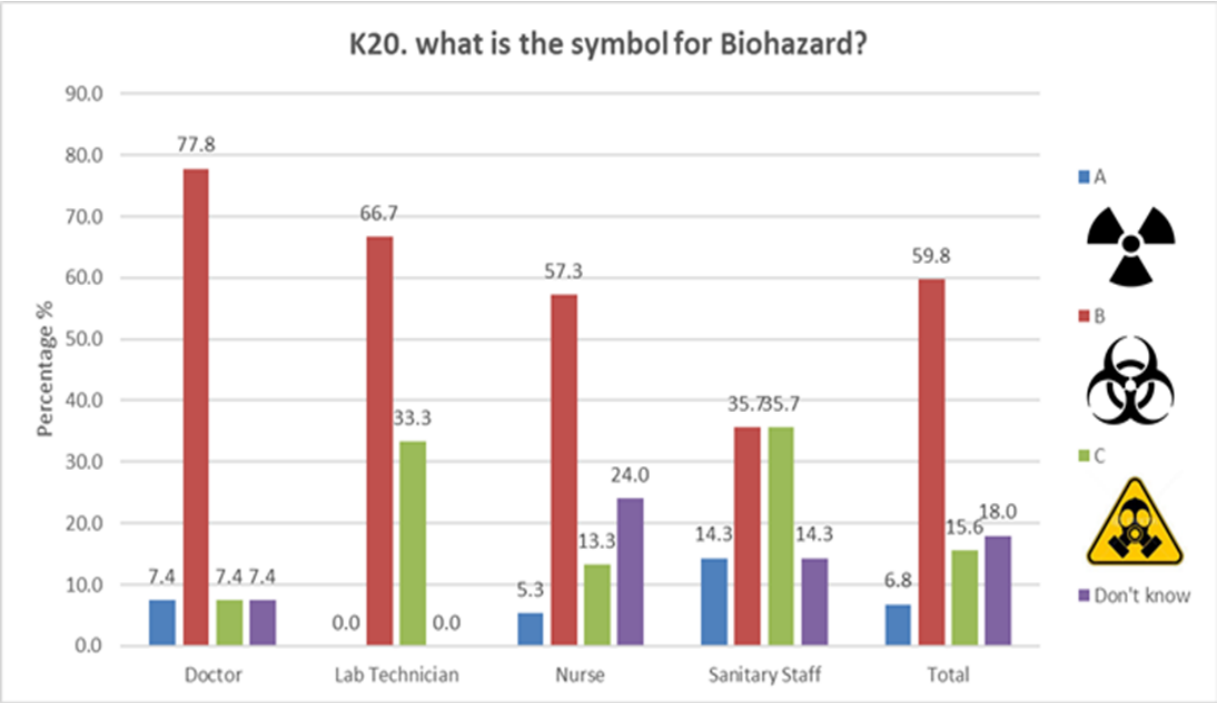


Figure 5: shows that the correct symbol for Biohazard waste is identified by (77.8%) doctors followed by lab technicians (66.7%), nurses (57.3%) and (35.7%) of the sanitary staff, which came out to be (59.8%) of the total health care workers.

Table 21: Distribution of the health care workers according to the knowledge regarding preparation of 1% sodium hypochlorite solution for disinfection.

Occupation	**K21. Do you know how to prepare 1L of 1% Sodium hypochlorite from available 5% strength?**		
	Yes (%)	No (%)	Total (100%)
Doctor	21 (77.8)	6 (22.2)	27
Lab Technician	4 (66.7)	2 (33.3)	6
Nurse	38 (50.7)	37 (49.3)	75
Sanitary Staff	3 (21.4)	11 (78.6)	14
Total	66 (54.1)	56 (45.9)	122

Table 21: shows that only about half 66 (54.1%) of the health care workers knew how to correctly prepare 1L of 1% Sodium hypochlorite from available 5% strength, which constituted 21 (77.8%) doctors, 4 (66.7%) lab technician 38 (50.7%) nurses and only 3 (21.4%) of sanitary staff.

Figure 6: Distribution of the health care workers according to the knowledge regarding the color coding for dustbin that are currently followed.

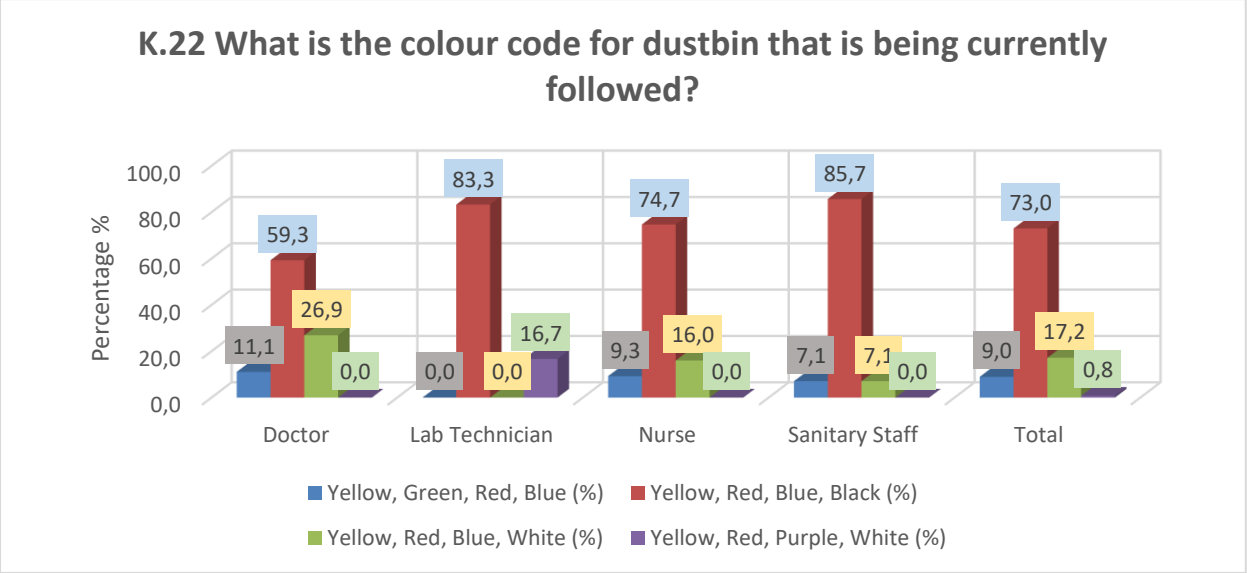


Table 22: Distribution of the health care workers according to the knowledge regarding the color coding for dustbin that are currently being followed.

Occupation	**K.22 What is the colour code for dustbin that is being currently followed?**				
	Yellow, Green, Red, Blue (%)	Yellow, Red, Blue, Black (%)	Yellow, Red, Blue, White (%)	Yellow, Red, Purple, White (%)	Total (100%)
Doctor	3 (11.1)	16 (59.3)	8 (26.9)	0 (0)	27
Lab Technician	0 (0)	5 (83.3)	0(0)	1 (16.7)	6
Nurse	7 (9.3)	56 (74.7)	12 (16.0)	0 (0)	75
Sanitary Staff	1 (7.1)	12 (85.7)	1 (7.1)	0 (0)	14
Total	11 (9.0)	89 (73.0)	21 (17.2)	1 (0.8)	122

Table 22: shows that 101 (82.78%) of the health care worker did not know the correct colour coding as per the revised 2016 biomedical waste management and handling rule. Among the 21 (17.2%) who correctly answered, 8(26.9%) were doctors, 12 (16%) were nurses and only 1 was (7.1%) sanitary staff worker. None of the lab technician knew the correct colour coding as per the revised 2016 biomedical waste management and handling rule.

Table 23: Distribution of the health care workers according to the knowledge regarding the transport of biomedical waste.

Occupation	**K23. Who regulates the safe transport of Biomedical Waste?**				
	Pollution Control Board of India (%)	Transport Corporation of India (%)	Private Corporation (%)	Don't know (%)	Total (100%)
Doctor	11 (40.7)	2 (7.4)	4 (14.8)	10 (37.0)	27
Lab Technician	3 (50.0)	2 (33.3)	0 (0)	1 (16.7)	6
Nurse	28 (37.3)	26 (34.7)	10 (13.3)	11 (14.7)	75
Sanitary Staff	2 (14.3)	1 (7.1)	7 (50)	4 (28.6)	14
Total	44 (36.1)	31 (25.4)	21 (17.2)	26 (21.3)	122

Table 23: shows that the 44 (36.1%) of the health care workers knew that pollution control board of India is responsible for the safe transportation of the biomedical waste. This number constituted 11 (40.7%) of doctors, 3 (50%) of lab technicians, 28 (37.3%) nurses and 2 (14.3%) of the sanitary staff workers

Picture 2: Appropriate color coding not being followed in Primary Health Centre Kakara.

Table 24: Practices followed by various Health care workers related to Biomedical Waste Management.

Practice related to BMWM	Doctor (%)	Lab Technician (%)	Nurse (%)	Sanitary Staff (%)	Total (%)
P1. Is Bio medical waste management being handled properly in your setup?					
Yes	27 (100)	5 (83.3)	58 (77.3)	8 (57.1)	98 (80.3)
No	0 (0)	1 (16.7)	17 (22.7)	6 (42.9)	24 (19.7)
P2. Are you following the revised biomedical waste management rule in your setup?					
Yes	27 (100)	6 (100)	58 (77.3)	8 (57.1)	99 (81.1)
No	0 (0)	0 (0)	17 (22.7)	6 (42.9)	23 (18.9)
P3. Do you follow the color coding of the biomedical waste management rule in your setup?					
Yes	27 (100)	6 (100)	62 (82.7)	8 (57.1)	103 (84.4)
No	0 (0)	0 (0)	13 (17.3)	6 (42.9)	19 (15.6)
P4. Do you separate/segregate different type of hospital waste in your setup?					
Yes	27 (100)	6 (100)	58 (77.3)	11 (78.6)	102 (83.6)
No	0 (0)	0 (0)	17 (22.7)	3 (21.4)	20 (16.4)

Table 24: Shows that 98 (80.3%) of the health care worker said that the biomedical waste management was proper in their setup.

Regrettably, 23 (18.9%) of the health care worker said that the revised biomedical waste management rules were not followed in their setup.

All of the doctors 27 (100%) and lab technicians 6 (100%), while 62 (82.7%) nurses and 8 (57.1%) sanitary workers, were following themselves the colour coding of the waste.

The practice of segregation of different type of waste was followed by all of the doctors 27 (100%) and lab technicians 6 (100%) but not followed by 17 (22.7%) of nurses, 3 (21.4%) of sanitary staff.

Table 25: Duration of biomedical waste management practices by various health care workers.

Occupation	**P5. Since when the new colour coding of the biomedical waste management rule is being followed in your setup?**				
	2015. (%)	2016. (%)	Not followed (%)	Don't know (%)	Total (%)
Doctor	4 (14.8)	10 (37.0)	0 (0)	13 (48.1)	27
Lab Technician	0 (0)	4 (66.7)	0 (0)	2 (33.3)	6
Nurse	10 (13.3)	36 (48.0)	8 (10.7)	21 (28.0)	75
Sanitary Staff	0 (0)	3 (21.4)	3 (21.4)	8 (57.1)	14
Total	14 (11.5)	53 (43.4)	11 (9.0)	44 (36.1)	122

Table 25: shows that 11 (9%) of the health care workers were still not following and 44 (36.1%) were not aware of the new colour coding rules.

The health care worker correctly following the new colour coding since 2016 were 11 (9%) constituting 10 (37%) doctors, 4 (66.7%) lab technician, 36 (48%) nurses and 3 (21.4%) sanitary staff.

Table 26: Practice regarding collection of Biomedical Waste by various health care workers.

Occupation	**P6. How do you collect different type of hospital waste?**				
	In single bag or container (%)	In separate color coded bag or container (%)	No Collection (%)	Don't know (%)	Total (%)
Doctor	1 (3.7)	26 (96.3)	0 (0)	0 (0)	27
Lab Technician	0 (0)	6 (100)	0 (0)	0 (0)	6
Nurse	17 (22.7)	56 (74.7)	0 (0)	2 (2.7)	75
Sanitary Staff	5 (35.7)	9 (64.3)	0 (0)	0 (0)	14
Total	23 (18.9)	97 (79.5)	0 (0)	2 (1.6)	122

Table 26: shows that while 97 (79.5%) of the health care worker knew that the biomedical waste is to be collected in separate colour coded bag but one doctor (3.7%), 17 (22.7%) nurses and 5 (35.7%) sanitary staff workers were collecting the bio medical waste in single bag or container.

Picture: 3 Primary Health Centre Bameta, were not using puncture proof plastic containers for sharps.

Table 27: Handling practices regarding Biomedical Waste by health care workers.

Practice related to BMWM	Doctor (%)	Lab Technician (%)	Nurse (%)	Sanitary Staff (%)	Total (%)
P7. Do you label hazardous waste separately, present in your health facilities?					
Yes	25 (92.6)	5 (83.3)	47 (62.7)	7 (50.0)	84 (68.9)
No	2 (7.4)	1 (16.7)	28 (37.3)	7 (50)	38 (31.1)
P8. Do you weigh the biomedical waste generated in your health facilities?					
Yes	18 (66.7)	2 (33.3)	31 (41.3)	4 (28.6)	55 (54.9)
No	9 (33.3)	4 (66.7)	44 (58.7)	10 (71.4)	67 (45.1)
P9. Do you wear PPE (Personal Protective Equipment) while handling Bio Medical Waste management?					
Yes	21 (77.8)	5 (83.3)	53 (70.7)	8 (57.1)	87 (71.3)
No	6 (22.2)	1 (16.7)	22 (29.3)	6 (42.9)	35 (28.7)
P10. Do you use puncture-proof plastic/cardboard container to collect waste sharp?					
Yes	25 (92.6)	6 (100)	50 (66.7)	7 (50)	88 (72.1)
No	2 (7.4)	0 (0)	25 (33.3)	7 (50)	34 (27.9)

Table 27: shows that 25 (92.6%) doctors 5 (83.3%) lab technicians, 47 (62.7%) nurses and 7 (50%) sanitary staff workers were labelling the hazardous waste separately.

A total of 55 (54.9%) of the various health care workers were weighing and 67 (45.1%) were not weighing the biomedical waste in their health facilities.

Most of the study participants 87 (71.3%) were wearing PPE and 35 (28.7%) were not, while handling biomedical waste.

Puncture proof containers for sharps waste were used by 25 (92.6%) doctors, 6 (100%) lab technician, 50 (66.7%) nurses and 7 (50%) sanitary staff.

Table 28: Practices regarding storage of Biomedical Waste Management by various health care workers.

Occupation	**P11. For how long you store biomedical waste in your setup?**				
	12 hour (%)	24 hour (%)	48 hour (%)	72 hour (%)	Total (%)
Doctor	10 (37.0)	15 (55.6)	1 (3.7)	1 (3.7)	27
Lab Technician	3 (50.0)	2 (33.3)	1 (16.7)	0 (0)	6
Nurse	26 (34.7)	28 (37.3)	6 (8.0)	15 (20.0)	75
Sanitary Staff	6 (42.9)	7 (50.0)	0 (0)	1 (7.1)	14
Total	45 (36.9)	52 (42.7)	8 (6.6)	17 (13.9)	122

Table 28: shows that 105 (86.2%) of health care workers were storing the biomedical waste for not more than 48 hours which the correct time limit as per the handling rule. Those not following were 15 (20%) nurses, 1 (3.7%) doctors and 1 (7.1%) sanitary staff workers. All lab technicians were following the correct time limit of storage.

Picture 5: No Dustbin was present in Indargari Sub Centre during Immunization

Table 29: Practice regarding plastic sheet used for Biomedical Waste Management

Occupation	**P12. What is the thickness of a plastic sheets provided in your health facility for different bins?**				
	25mm (%)	50mm (%)	70mm (%)	75mm (%)	Total (%)
Doctor	8 (29.6)	14 (51.9)	2 (7.4)	3 (11.1)	27
Lab Technician	2 (33.3)	4 (66.7)	0 (0)	0 (0)	6
Nurse	26 (34.7)	21 (28.0)	6 (8.0)	22 (29.3)	75
Sanitary Staff	6 (42.9)	2 (14.3)	3 (21.4)	3 (21.4)	14
Total	42 (34.4)	41 (33.6)	11 (9.0)	28 (23.0)	122

Table 29: shows that one third 41 (33.6%) of the health care worker using appropriate plastic sheets of 50mm for the biomedical waste management. Of them 14 (51.9%) were doctors, 4(66.7%) were lab technicians, 21 (28%) were nurses and 2 (14.3%) were sanitary staff workers.

Table 30: Practice regarding reporting of injuries and accidents due to Biomedical Waste Management.

Occupation	**P13. Do you have a system of reporting injuries and accidents due to Bio-medical waste?**		
	Yes (%)	No (%)	Total (%)
Doctor	23 (85.2)	4 (14.8)	27
Lab Technician	5 (83.3)	1 (16.7)	6
Nurse	50 (66.7)	25 (33.3)	75
Sanitary Staff	10 (71.4)	4 (28.6)	14
Total	88 (72.1)	34 (27.9)	122

Table 30: shows that the majority 88 (72.1%) of the health care workers were having a system of reporting injuries and accident due to biomedical waste. On the other hand, 4 (14.8%) doctors, 1 (16.7%) lab technician, 25 (33.3%) nurses and 4 (28.6%) reported that they didn't have such system of reporting injuries and accident due to biomedical waste.

Table 31: Time taken practice to report any hazardous event due to Biomedical Waste Management.

Occupation	**P14. How much time was taken to report any hazardous event occurred due to bio medical waste in your setup?**				
	12 hour (%)	24 hour (%)	48 hour (%)	No such event occurred (%)	Total (%)
Doctor	13 (48.1)	7 (25.9)	1 (3.7)	6 (22.2)	27
Lab Technician	5 (83.3)	0 (0)	0 (0)	1 (16.7)	6
Nurse	42 (56.0)	9 (12.0)	9 (12.0)	21 (28.0)	75
Sanitary Staff	8 (57.1)	2 (14.3)	2 (14.3)	1 (7.1)	14
Total	68 (55.7)	18 (14.8)	7 (5.7)	29 (23.8)	122

Table 31: shows that 86 (70.4%) health care workers were reporting any hazardous event due to biomedical waste management within 24 hours. However, 29 (23.8%) participants informed that none such hazardous event had ever occurred due to bio medical waste management.

Also 7 (5.7%) healthcare worker was following the wrong practice of reporting the hazardous event in 48 hours.

Picture 4: Mixing of yellow colour category infectious waste with blue category in Primary Health Centre Bhojpur.

Table 32: Practice regarding precautionary measure of healthcare worker while Biomedical Waste Management

Practice related to BMWM	Doctor (%)	Lab Technician (%)	Nurse (%)	Sanitary Staff (%)	Total (%)
P15. Have you been immunized against Hepatitis B?					
Yes	25 (92.6)	6 (100)	60 (80.0)	8 (57.1)	99 (81.1)
No	2 (7.4)	0 (0)	15 (20.0)	6 (42.9)	23 (18.9)
P16. Do you follow PEP after needle stick injury or percutaneous injury?					
Yes	26 (96.3)	0 (0)	62 (82.7)	7 (50)	101 (82.8)
No	1 (3.7)	6 (100)	13 (17.3)	7 (50)	21 (17.2)
P17. Do you put infectious waste in black container?					
Yes	7 (25.9)	5 (83.3)	20 (26.7)	2 (14.3)	34 (27.9)
No	20 (74.1)	1 (16.7)	55 (73.3)	12 (85.7)	88 (72.1)

Table 32: shows that all of the lab technician 6 (100%), 25 (92.6%) doctors, 60 (80%) nurses and 8 (57.1%) sanitary staff workers, were immunized against Hepatitis B.

After needle stick injury or percutaneous injury, it was observed that 101 (82.8%) were taking but 21 (17.2%) were not taking the post exposure prophylaxis.

Worryingly 34 (27.9%) of the health care workers were putting the infectious waste in black container.

Table 33: Practice regarding preparation of sodium hypochlorite for Biomedical Waste Management.

Occupation	**P18.How do you prepare 1L of 1% Sodium hypochlorite from available 5% strength?**				
	1000ml of water + 500ml of Sodium hypochlorite(%)	250ml of water + 500ml of Sodium hypochlorite (%)	500ml of water + 200ml of Sodium hypochlorite(%)	800ml of water + 200ml of Sodium hypochlorite (%)	Total (%)
Doctor	5 (18.5)	2 (7.4)	7 (25.9)	13 (48.1)	27
Lab Technician	1 (16.7)	0 (0)	4 (66.7)	1 (16.7)	6
Nurse	30 (40.0)	10 (13.3)	15 (20.0)	20 (26.7)	75
Sanitary Staff	7 (50.0)	2 (14.3)	4 (28.6)	1 (7.1)	14
Total	43 (35.2)	14 (11.5)	30 (24.6)	35 (28.7)	122

Table 33: shows that the nearly one fourth 35 (28.7%) of the health care workers knew the correct preparation for 1% for Sodium hypochlorite for biomedical waste management. This included 13 (48.1%) doctors, 1 (16.7%) lab technician, 20 (26.7%) nurses and 1 (7.1%) sanitary staff workers.

Table 34: Practice regarding maintenance of registers for Biomedical Waste Management.

Occupation	**P19. Do you maintain a register for Biomedical waste disposal in your setup?**		
	Yes (%)	No (%)	Total (%)
Doctor	20 (74.1)	7 (25.9)	27
Lab Technician	5 (83.3)	1 (16.7)	6
Nurse	55 (73.3)	20 (26.7)	75
Sanitary Staff	6 (42.9)	8 (57.1)	14
Total	86 (70.5)	36 (29.5)	122

Table 34: shows that majority of the health care workers 86 (70.5%) were following the good practice of maintaining a register in their health setup.

However, the register was not maintained by a substantial number of 36 (29.5%) health care workers.

Table 35: Practice regarding safe transport of Biomedical Waste Management.

Occupation	**P20. In your health facility which agency is assigned for safe transport of Bio Medical Waste management?**				
	State (%)	Private (%)	No regulation (%)	Don't Know (%)	Total (%)
Doctor	16 (59.3)	7 (25.9)	0 (0)	4 (14.8)	27
Lab Technician	5 (83.3)	1 (16.7)	0 (0)	0 (0)	6
Nurse	36 (48.0)	25 (33.3)	8 (10.7)	6 (8.0)	75
Sanitary Staff	1 (7.1)	6 (42.9)	1 (7.1)	6 (42.9)	14
Total	58 (47.5)	39 (32.0)	9 (7.4)	16 (13.1)	122

Table 35: shows that nearly one third 39 (32%) of health care workers said that a private agency while almost half of them 58 (47.5%) said that a state agency, is assigned for safe transport for biomedical waste management.

Some of the study participant 16 (13.1%) were not aware of the any responsibility regarding the safe transport of the biomedical waste.

Picture 6: Interviewing Lab Technician in Primary Health Centre, Gyaspur.

Table 36: Practice regarding wearing of protective gear while handling Biomedical Waste.

Occupation	**P21 What precautions do you take while handling Biomedical Waste?**			
	Gloves (%)	Mask (%)	Goggle (%)	PPE (%)
Doctor	27 (100)	27(100)	21 (81.5)	24 (88.9)
Lab Technician	06 (100)	6 (100)	05 (83.3)	05 (83.3)
Nurse	71 (94.7)	61 (81.3)	53 (70.7)	57 (76.0)
Sanitary Staff	14 (100)	9 (64.3)	06 (42.9)	7 (50)
Total	118(96.7)	103 (84.4)	86 (70.5)	93 (76.2)

Table 36: Show that among the doctors 27 (100%), 27 (100%), 21 (81.5%) and 24 (88.9%) respectively wear gloves, mask, goggle and PPE while handling biomedical waste.

In case of sanitary staff workers, the result was 14(100%), 9 (64.3%), 6 (42.9%) and 7 (50%), while in case of nurses it was 71 (94.7%), 61 (81.3%), 53 (70.7%) and 57 (76%) for gloves, mask, goggles and PPE respectively.

While all the 6 (100%) lab technicians were wearing gloves and mask, 5 (83.3%) were wearing google and PPE each while handling biomedical waste.

Table 37 Biomedical waste management knowledge of COVID-19 protective gear.

Occupation	**A1. Personal protective equipment used in COVID19 like goggles, face shield and gloves are disposed in?**				
	Red bin (%)	Yellow bin (%)	Black Bin (%)	Don't know (%)	Total (%)
Doctor	13 (48.1)	9 (33.3)	2 (7.4)	3 (11.1)	27
Lab Technician	3 (50.0)	2 (33.3)	1 (16.7)	0 (0)	6
Nurse	22 (29.3)	37 (49.3)	11 (14.7)	5 (6.7)	75
Sanitary Staff	4 (28.6)	6 (42.9)	0 (0)	4 (28.6)	14
Total	42 (34.4)	54 (44.3)	14 (11.5)	12 (9.8)	122

Table 37: Shows that 13 (48.1%) doctors, 3 (50%) lab technicians, 22 (29.3%) nurses and 4 (28.6%) sanitary staff workers, knew that goggle, face shield and gloves used in COVID 19 are to be disposed in red bins.

Unfortunately, 54 (44.3%), 14 (11.5%) were wrongly throwing them in yellow and black bins respectively.

Moreover 12 (9.8%) of the health care worker didn’t know correct method of disposal of COVID 19 protective gear.

Table 38: Biomedical waste management knowledge regarding disposal of used COVID-19 protective equipment.

Occupation	**A2. Personal protective equipment used in COVID19 like Used mask (N95) are disposed in?**				
	Yellow bin (%)	Red bin (%)	Black Bin (%)	Don't know (%)	Total (%)
Doctor	11 (40.7)	9 (33.3)	3 (11.1)	4 (14.8)	27
Lab Technician	2 (33.3)	3 (50.0)	1 (16.7)	0 (0)	6
Nurse	39 (52.0)	14 (11.5)	16 (21.3)	6 (8.0)	75
Sanitary Staff	6 (42.9)	5 (35.7)	0 (0)	3 (21.4)	14
Total	58 (47.5)	31 (25.4)	20 (16.4)	13 (10.7)	122

Table 38: Shows that 11 (40.7%) doctors, 2 (33.3%) lab technician, 39 (52%) nurses and6 (42.9%) sanitary staff workers, were correctly disposing the used COVID 19 protective equipment like mask in yellow bin

Unfortunately, 31 (25.4%), 20 (16.4%) were wrongly disposing them in red and black bins respectively.

Moreover 13 (10.7%) of the health care worker didn’t know correct method of disposal of used COVID 19 protective equipment.

Table 39: Knowledge regarding use of double layer bags for COVID-19 waste collection.

Occupation	**A3. How many layered bags are used for collection of waste from COVID-19 to ensure zero-leaks?**				
	Single (%)	Double (%)	Triple (%)	Don't know (%)	Total (%)
Doctor	1 (3.7)	16 (59.3)	6 (22.2)	4 (14.8)	27
Lab Technician	0 (0)	5 (83.3)	1 (16.7)	0 (0)	6
Nurse	9 (12.0)	44 (58.7)	8 (10.7)	14 (18.7)	75
Sanitary Staff	2 (14.3)	6 (42.9)	1 (7.1)	5 (35.7)	14
Total	12 (9.8)	71 (58.2)	16 (13.1)	23 (18.9)	122

Table 39: Show that a little less than three fourth 71 (58.2%) of the total health care worker including 16 (59.3%) doctors, 5 (83.3%) lab technician, 44(58.7%) nurses and 6 (42.9%) sanitary workers correctly knew about the use of double layered bags for collection of COVID-19 waste.

Importantly, 23(18.9%) of the participant were unware of any such practices.

Table 40: Knowledge of the duration of the COVID-19 waste disposal.

Occupation	**A4. Biomedical waste generated from COVID-19 related activities should be strictly disposed of within?**				
	12 hour (%)	24 hour (%)	48 hour (%)	Don't know (%)	Total (%)
Doctor	16 (59.3)	10 (37.0)	0 (0)	1 (3.7)	27
Lab Technician	3 (50.0)	1 (16.7)	1 (16.7)	1 (16.7)	6
Nurse	48 (64.0)	14 (18.7)	2 (2.7)	11 (14.7)	75
Sanitary Staff	10 (71.4)	1 (7.1)	1 (7.1)	2 (14.3)	14
Total	77 (63.1)	26 (21.3)	4 (3.3)	15 (12.3)	122

Table 40: Shows that 77 (63.1%) and 26 (21.3%) of the health care worker knew to dispose off COVID-19 waste in 12 hours and 24 hours respectively, the latter being prescribed method.

The wrong knowledge of disposing in 48 hours was reported by 4 (3.3%) and a still higher number 15 (12.3%) of health care workers were unaware about the correct method.

Table 41: Knowledge regarding COVID-19 plastic overall disposal.

Occupation	**A5. Health care worker working in a COVID ward should dispose of the plastic overall in _____.**				
	Red bin (%)	Yellow bin (%)	Black Bin (%)	Don't know (%)	Total (%)
Doctor	12 (44.4)	9 (33.3)	2 (7.4)	4 (14.8)	27
Lab Technician	1 (16.7)	3 (50.0)	2 (33.3)	0 (0)	6
Nurse	24 (32.0)	29 (38.7)	11 (14.7)	11 (14.7)	75
Sanitary Staff	3 (21.4)	4 (28.6)	3 (21.4)	4 (28.6)	14
Total	40 (32.8)	45 (36.9)	18 (14.8)	19 (15.6)	122

Table 41: Shows that 40 (32.8%) of the health workers said correctly that the plastic overall used were disposed off in red bins. On the other hand, 45 (36.9%) and 18 (14.8%) answered wrongly yellow and black bin respectively and 19 (15.6%) were unaware about the correct options.

Table 42: Biomedical waste management knowledge of COVID-19 protective gear.

Occupation	**A6. Inner & outer surface of Bio-Medical Waste containers from COVID 19 must be disinfected daily with?**				
	0.5% Formaldehyde (%)	1 % Sodium Hypochlorite (%)	2% Methyl Bromide (%)	Don't know (%)	Total (%)
Doctor	5 (18.5)	21 (77.8)	0 (0)	1 (3.7)	27
Lab Technician	1 (16.7)	5 (83.3)	0 (0)	0 (0)	6
Nurse	9 (12.0)	41 (54.7)	0 (0)	25 (33.3)	75
Sanitary Staff	1 (7.1)	4 (28.6)	0 (0)	9 (64.3)	14
Total	16 (13.1)	71 (58.2)	0 (0)	35 (28.7)	122

Table 42: Shows that more than half 71 (58.2%) of the health care workers correctly knew that the inner and the outer surface of biomedical waste container from COVID-19 must be disinfected daily with 1 % Sodium Hypochlorite.

Also 16 (13.1%) answered 0.5% Formaldehyde and 35 (28.7%) didn’t know about the daily disinfection of COVID-19 waste containers.

Table 43: Knowledge regarding labelling COVID 19 Biomedical waste.

Occupation	**A7. Is it mandatory for all Bio-Medical Waste bags & containers from COVID 19 area to carry COVID 19 Waste label?**		
	Yes (%)	No (%)	Total (%)
Doctor	25 (92.6)	2 (7.4)	27
Lab Technician	6 (100)	0 (0)	6
Nurse	7 (9.3)	68 (90.7)	75
Sanitary Staff	5 (35.7)	9 (64.3)	14
Total	108 (88.5)	14 (11.5)	122

Table 43: Shows that only 14 (11.5%) of the health care worker didn't know that COVID-19 waste bag and container need to be labeled while 25 (92.6%) doctors, 6(100%) lab technicians, 7 (9.3%) nurses and 5 (35.7%) of sanitary staff workers knew about this mandate.

Table 44: Knowledge regarding the name of the COVID 19 Biomedical waste App.

Occupation	**A8. What is the name of the App developed by the State pollution control board for the record of BMW generated from COVID-19**				
	AROGYA SETU (%)	COVID19BMW (%)	COVIN BMW (%)	Don't know (%)	Total (%)
Doctor	3 (11.1)	11 (40.7)	3 (11.1)	10 (37.0)	27
Lab Technician	1 (16.7)	2 (33.3)	0 (0)	3 (50.6)	6
Nurse	9 (12.0)	16 (21.3)	20 (26.7)	30 (40.0)	75
Sanitary Staff	0 (0)	0 (0)	0 (0)	14 (100)	14
Total	13 (10.7)	29 (23.8)	23 (18.9)	57 (46.7)	122

Table 44: shows that COVID 19 BMW is the name of the application developed by the state pollution control board was known by only 29 (23.8%) of the health care workers and most of them 56 (46.7%) were unware about it.

Plus, Arogyasetu and COVIN BMW were wrongly named by 13 (10.7%) and 23 (18.9%) respectively, as the names of the App.

Table 45 Knowledge regarding disposal of Biomedical waste in remote COVID 19 quarantine centers.

Occupation	**A9. What is the method for handling Bio medical waste, generated from COVID19 by remote quarantine centres in rural area?**				
	Deep burial (%)	Microwaving (%)	Recycling (%)	Don't know (%)	Total (%)
Doctor	17 (63.0)	3 (11.1)	0 (0)	7 (25.9)	27
Lab Technician	2 (33.3)	0 (0)	1 (16.7)	3 (50.0)	6
Nurse	44 (58.7)	3 (4.0)	3 (4.0)	25 (33.3)	75
Sanitary Staff	1 (7.1)	0 (0)	0 (0)	13 (92.9)	14
Total	64 (52.5)	6 (4.9)	4 (3.3)	48 (39.3)	122

Table 45: Shows that deep burial as the preferred method for disposing COVID 19 waste from remote quarantine center was known by 64 (52.5%) while 6 (4.9%) and 4 (3.3%) thought it to be microwaving and recycling respectively.

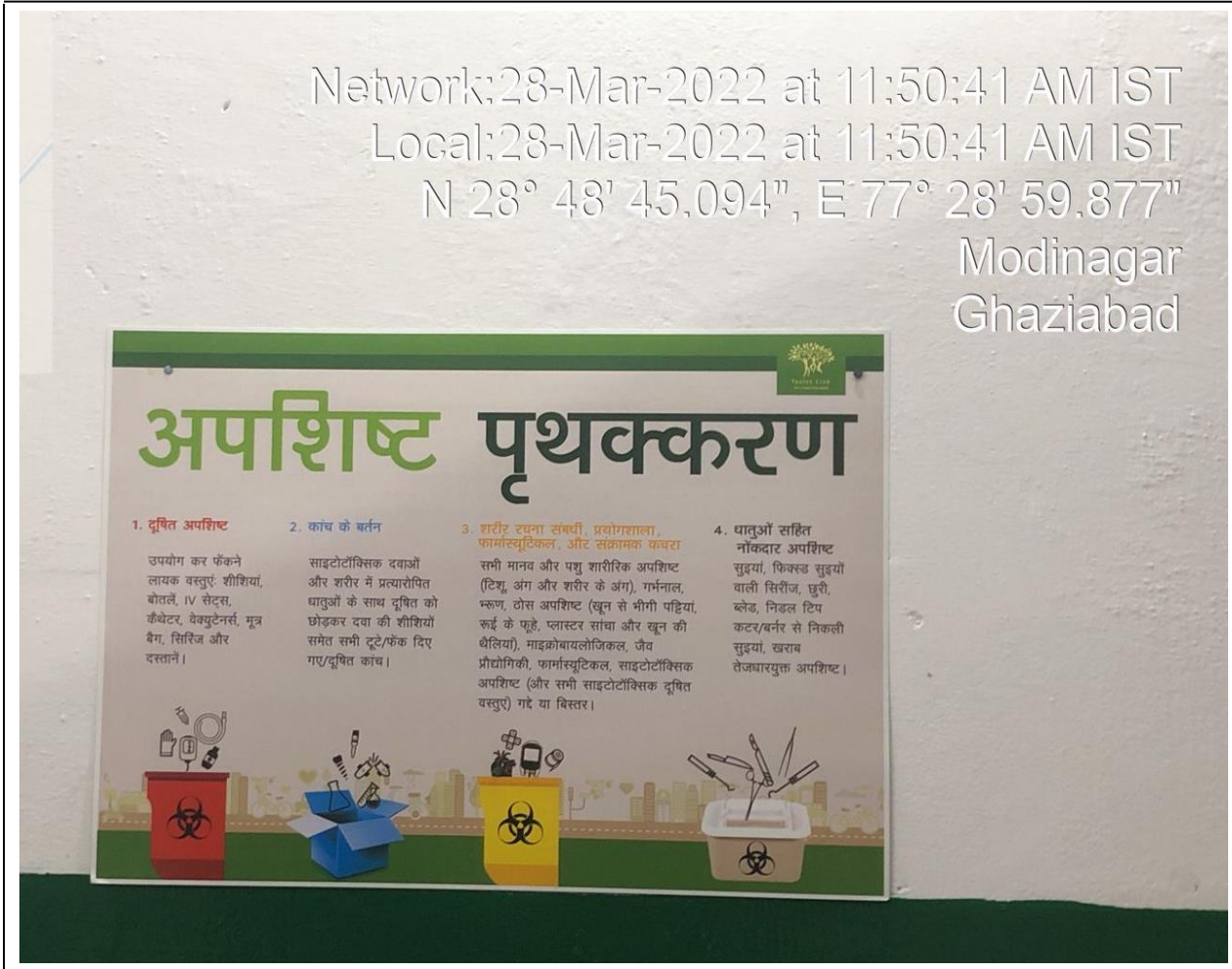
Table 46: Practice regarding availability of various resources regarding Biomedical waste management of COVID-19.

COVID-19 Practice regarding Biomedical waste.	Doctor (%)	Lab Technician (%)	Nurse (%)	Sanitary Staff (%)	Total (%)
A10. Do you have separate color coded bin with foot operated lids for Bio-Medical Waste generated from COVID 19?					
Yes	25 (92.6)	4 (66.7)	52 (69.3)	9 (64.3)	86 (70.5)
No	2 (7.4)	2 (33.3)	23 (30.7)	5 (35.7)	36 (29.5)
A11. Do you maintain separate record of waste generated from COVID-19?					
Yes	17 (63.0)	4 (66.7)	44 (58.7)	2 (14.3)	67 (54.9)
No	10 (37.0)	2 (33.3)	31 (41.3)	12 (85.7)	55 (45.1)
A12. Does your health center have dedicated sanitation workers deputed only for collection of COVID 19 Biomedical waste?					
Yes	20 (74.1)	4 (66.7)	46 (61.3)	1 (7.1)	71 (58.2)
No	7 (25.9)	2 (33.3)	29 (38.7)	13 (92.9)	51 (41.8)

Table 46: shows that among the 86 (70.5%) of the healthcare workers who were using separate colour coded bin with foot operated lids for COVID 19 waste disposal, the maximum was doctors 25 (92.6%) and the minimum were sanitary staff workers 9 (64.3).

A separate record for COVID 19 waste generated was maintained by 17 (63%) doctors, 4 (66.7%) lab technicians, 44 (58.7%) nurses and 2 (14.3%) sanitary staff.

A total of 51 (41.8%) of the staff did not have dedicated sanitation workers deputed only for collection of COVID 19 biomedical waste and 71 (58.2%) had the dedicated sanitation workers.



Picture 7: Banner and Charts present in Community Health Centre, Modinagar

Table 47: Biomedical waste management knowledge of COVID-19

Practice regarding Biomedical waste	Doctor (%)	Lab Technician (%)	Nurse (%)	Sanitary Staff (%)	Total (%)
A13. Did you attend any government certified training regarding Hospital Waste Management & Handling?					
Yes	10 (37.0)	6 (100)	40 (53.3)	4 (28.6)	61 (50)
No	17 (63.0)	0 (0)	35 (46.7)	10 (71.4)	61 (50)
A14. Does your center have any facility for storage of Bio- medical waste?					
Yes	25 (92.6)	5 (83.3)	45 (60.0)	9 (64.3)	84 (68.9)
No	2 (7.4)	1 (16.7)	30 (40)	5 (35.7)	38 (31.1)
A15. Are any banner/chart showing Biomedical waste collection, segregation & disposal present in your health facility?					
Yes	23 (85.2)	5 (83.3)	56 (74.6)	9 (64.3)	93 (76.2)
No	4 (14.8)	1 (16.7)	19 (25.3)	5 (35.7)	29 (23.8)

Table 47: shows that exactly half 61 (50%) of the total healthcare workers had and half 61 (50%) had not attended any government certified training regarding hospital waste management. Notably majority of the sanitary staff workers 10 (71.4%) and doctors 17 (63.0%) had not attended any government certified training regarding Hospital Waste Management.

Two third of the health care workers 84 (68.9%) had a facility for storage of Biomedical waste in their centers but 38 (31.1%) did not have one.

Banners/charts showing biomedical waste collection, segregation and disposal, were reported to be present by 23 (85.2%) doctors, 5 (83.3%) lab technician, 56 (74.6%) nurses and 9 (64.3%) of sanitary staff workers, at their health facilities.

Table 48: General Knowledge of Biomedical waste management.

Variable	Category	**General Knowledge of BMWM**		Total (100%)	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	16 (61.5)	10 (38.5)	26	0.257	
	Female	47 (49)	49 (51)	96	Reference	
Education	10th Pass	6 (60)	4(40)	10	0.226	
	12th Pass	1 (33.3)	2 (66.7)	3	0.832	
	Diploma	28 (39.4)	43 (60.6)	71	Reference	
	Graduate	19 (76)	6 (24)	25	0.003*	4.863 (1.729-13-675)
	Post Graduate	9 (69.2)	4 (30.8)	13	0.056	
Occupation	Doctor	19 (70.4)	8 (29.6)	27	0.012*	3.371 (1.310-8.675)
	Lab Technician	5 (833)	1 (16.7)	6	0.08	
	Nurse	31 (41.3)	44 (58.7)	75	Reference	
	Sanitary Staff	8 (57.1)	6 (42.9)	14	0.279	
Health Facilities	C.H.C (Community health center)	19 (73.1)	7 (26.9)	26	0.003*	4.825 (1.703-13.671)
	P.H.C (Primary Health Center)	26 (56.5)	20 (43.5)	46	0.045*	2.311 (1.017-5.250)
	Sub- Center	18 (36)	32 (64)	50	Reference	

Table 48: Shows that a significant association was found between level of education and general knowledge of biomedical waste management. Knowledge of graduate was almost five times higher 4.863 (1.729-13-675) than diploma holders.

Doctors had three times higher 3.371 (1.310-8.675) general knowledge of biomedical waste management than nurses.

General knowledge was almost five times higher 4.825 (1.703-13.671) among the CHC staff and two times higher 2.311 (1.017-5.250) among PHC staff than sub-center staff

No significant association was found between general knowledge regarding biomedical waste and gender.

Table 49: Knowledge Regarding Handling rule of BMWM

Variable	Category	**Knowledge Regarding Handling rule of BMWM**		Total (100%)	p value
		Good (%)	Bad (%)		
Gender	Male	16 (61.5)	10 (38.5)	26	0.425
	Female	67 (69.8)	29 (30.2)	96	Reference
Education	10th Pass	7 (70)	3 (30)	10	0.811
	12th Pass	1 (33.3)	2 (66.7)	3	0.275
	Diploma	47 (66.2)	24 (33.8)	71	Reference
	Graduate	18 (72)	7 (28)	25	0.594
	Post Graduate	10 (76.9)	3 (23.1)	13	0.45
Occupation	Doctor	19 (70.4)	8 (29.6)	27	0.82
	Lab Technician	4 (66.7)	2 (33.3)	6	0.946
	Nurse	51 (68)	24 (32)	75	Reference
	Sanitary Staff	9 (64.3)	5 (35.7)	14	0.786
Health Facilities	C.H.C (Community health center)	20 (76.9)	6 (23.1)	26	0.107
	P.H.C (Primary Health Center)	34 (73.9)	12 (26.1)	46	0.103
	Sub- Center	29 (58)	21 (42)	50	Reference

Table 49: shows that 16 (61.5%) male and 67 (69.8%) female had good knowledge regarding handling rule of Biomedical waste management and maximum of them were doctors 19 (70.4%) followed by nurse 51 (68%), lab technician 4 (66.7%) and sanitary staff workers 9 (64.3%)

Among the 10^{th} pass of the study subject 7 (70%), 12^{th} pass subjects only 1 (33.3%), diploma holder 47 (66.2%), graduate 18 (72%) and post graduate10 (76.9%) had good knowledge regarding handling biomedical waste.

In CHCs and PHCs almost one fourth each of the health workers 6 (23.1), 12 (26.1) respectively had bad knowledge regarding handling of biomedical waste, while the numbers rose to 21 (42%) in case of Sub-centres.

Table 50: Knowledge Regarding Precautionary measure of BMWM

Variable	Category	**Knowledge Regarding Precautionary measure of BMWM**		Total (100%)	p value
		Good (%)	Bad (%)		
Gender	Male	20 (76.9)	6 (23.1)	26	0.375
	Female	81 (84.4)	15 (15.6)	96	Reference
Education	10th Pass	6 (60)	4 (40)	10	0.055
	12th Pass	3 (100%)	0 (0)	3	0.999
	Diploma	61 (85.9)	10 (14.1)	71	Reference
	Graduate	21 (84)	4 (16)	25	0.816
	Post Graduate	10 (76.9)	3 (23.1)	13	0.415
Occupation	Doctor	22 (81.5)	5 (18.5)	27	0.638
	Lab Technician	5 (83.3)	1 (16.7)	6	0.895
	Nurse	64 (85.3)	11 (14.7)	75	Reference
	Sanitary Staff	10 (71.4)	4 (28.6)	14	0.211
Health Facilities	C.H.C (Community health center)	22 (84.6)	4 (15.4)	26	0.944
	P.H.C (Primary Health Center)	37 (80.4)	9 (19.6)	46	0.648
	Sub- Center	42 (84)	8 (16)	50	Reference

Table 50: shows that 20 (76.9%) male and 81(84.4%) female had good knowledge regarding precautionary measure of Biomedical waste management and maximum of them were nurse 64 (85.3%) followed by lab technician 5 (83.3%), 22 (81.5%)doctors and sanitary staff workers 10 (71.4%)

Among the 10^{th} pass of the study subject 6 (60%), 12^{th} pass subjects all 3 (100%), diploma holder 61 (85.9%), graduate 21 (84%) and post graduate10 (76.9%) had good knowledge regarding precautionary measure of Biomedical waste.

In CHCs and PHCs health care workers 4 (15.4), 9 (19.6) respectively had bad knowledge regarding precautionary measure of Biomedical waste, while only 8(16%) in case of Sub-centers had bad knowledge regarding precautionary measure of Biomedical waste.

Table 51: Knowledge Regarding Hazard of BMWM

Variable	Category	**Knowledge Regarding Hazard of BMWM**		Total (100%)	p value
		Good (%)	Bad (%)		
Gender	Male	16 (68.5)	10 (38.5)	26	0.629
	Female	54 (56.30	42 (43.8)	96	Reference
Education	10th Pass	4 (40)	6 (60)	10	0.381
	12th Pass	1 (33.3)	2 (66.7)	3	0.475
	Diploma	39 (54.9)	32 (45.1)	71	Reference
	Graduate	17 (68)	8 (32)	25	0.257
	Post Graduate	9 (69.2)	4 (30.8)	13	0.343
Occupation	Doctor	20 (74.1)	7 (25.9)	27	0.082
	Lab Technician	4 (66.7)	2 (33.3)	6	0.573
	Nurse	41 (54.7)	34 (45.3)	75	Reference
	Sanitary Staff	5 (35.7)	9 (64.3)	14	0.2
Health Facilities	C.H.C (Community health center)	18 (69.2)	8 (30.8)	26	0.112
	P.H.C (Primary Health Center)	27 (58.7)	19 (41.3)	46	0.394
	Sub- Center	25 (50)	25 (50)	50	Reference

Table 51: shows that 16 (68.5%) male and 54(56.3%) female had good knowledge regarding hazards of Biomedical waste management and maximum of them were doctors 20 (74.1%) followed by lab technician 4 (66.7%), nurse 41 (54.7%) and sanitary staff workers 5 (35.7%)

Among the 10^{th} pass of the study subject 4 (40%), 12^{th} pass subjects all 1 (33.3%), diploma holder 39 (54.7%), graduate 17 (68%) and post graduate 9 (69.2%) had good knowledge regarding hazards of Biomedical waste.

In CHCs and PHCs health care workers 8 (30.8), 19 (41.3) respectively had bad knowledge regarding hazards of Biomedical waste, while 25 (50%) in case of Sub-centers had bad knowledge regarding hazardous of Biomedical waste.

Table 52: Total Knowledge of Health care workers Regarding Biomedical waste management.

Variable	Category	**Total Knowledge of BMWM**		Total (100%)	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	16 (61.50)	10 (38.5)	26	0.928	
	Female	66 (62.5)	36 (37.50	96	Reference	
Education	10th Pass	5 (50%)	5 (50%)	10	0.706	
	12th Pass	1 (33.3)	2 (66.7)	3	0.447	
	Diploma	40 (56.3)	31(33.7)	71	Reference	
	Graduate	19 (76)	6 (24)	25	0.088	
	Post Graduate	11 (84.6)	2 (15.4)	13	0.072	
Occupation	Doctor	22 (81.5)	5 (18.5)	27	0.03*	3.274 (1.119-9.579)
	Lab Technician	4 (66.7)	2 (33.3)	6	0.657	
	Nurse	43 (57.3)	32 (42.7)	75	Reference	
	Sanitary Staff	7 (50)	7 (50)	14	0.612	
Health Facilities	C.H.C (Community health center)	22 (84.6)	4 (15.4)	26	0.005*	5.5 (1.655-18.278)
	P.H.C (Primary Health Center)	29 (63)	17 (37)	46	0.2	
	Sub- Center	25 (50)	25 (50)	50	Reference	

Table 52: Shows that a significant association was found between occupation and Total knowledge of biomedical waste management. Knowledge of doctors had three times higher 3.274 (1.119-9.579) total knowledge of biomedical waste management than nurses.

Total knowledge was five times higher 5.5 (1.655-18.278) among the CHC than sub-centre staff.

Table 53: General Practice of Health care workers regarding Biomedical waste management.

Variable	Category	**General Practice BMWM**		Total	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	17(65.4)	09 (34.6)	26	0.23	
	Female	50 (52.1)	46 (47.9)	96	Reference	
Education	10th Pass	5 (50)	5 (50)	10	0.706	
	12th Pass	2 (66.7)	1 (33.3)	3	0.447	
	Diploma	31 (43.7)	40 (56.3)	71	Reference	
	Graduate	19 (76)	6 (24)	25	0.007*	4.086 (1.458-11.453)
	Post Graduate	10 (76.9)	3 (23.1)	13	0.037*	4.301 (1.090-16.974)
Occupation	Doctor	22 (81.5)	5 (18.5)	27	0.003*	5.029 (1.722-14.686)
	Lab Technician	3 (50)	3 (50)	6	0.875	
	Nurse	35 (46.7)	40 (53.3)	75	Reference	
	Sanitary Staff	7 (50)	7 (50)	14	0.819	
Health Facilities	C.H.C (Community health center)	21 (80.8)	5 (19.2)	26	0.001*	7.467 (2.404-23.194)
	P.H.C (Primary Health Center)	28 (60.9)	18 (39.1)	46	0.016*	2.765 (1.209-6.324)
	Sub- Center	18 (36)	32 (64)	50	Reference	

Table 53: Shows that a significant association was found between education level and general practice of biomedical waste management. General practice was four times better 4.086 (1.458-11.453) in graduate and 4.301 (1.090-16.974) in post graduate than diploma holders.

Doctors had five time better 5.029 (1.722-14.686) general practice of biomedical waste management than nurses.

General practice was seven times better 7.467 (2.404-23.194) among the CHC staff and two times higher 2.765 (1.209-6.324) among PHC staff than sub-center staff.

No significant association was found between general knowledge regarding biomedical waste and gender.

Table 54: Practice Regarding Handling Rule of Health care workers regarding Biomedical waste management.

Variable	Category	**Practice Regarding Handling Rule BMWM**		Total (100%)	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	19 (73.1)	7 (26.9)	26	0.088	
	Female	52 (54.2)	44 (45.8)	96	Reference	
Education	10th Pass	5 (50)	5 (50)	10	0.835	
	12th Pass	1 (33.3)	2 (66.7)	3	0.658	
	Diploma	33 (46.5)	38 (58.5)	71	Reference	
	Graduate	21 (84)	4 (16)	25	0.003*	6.045 (1.883-19.411)
	Post Graduate	11 (84.6)	2 (15.4)	13	0.022*	6.33 (1.308-30.661)
Occupation	Doctor	25 (92.6)	2 (7.4)	27	0.001*	13.542 (2.992-61.289)
	Lab Technician	3 (50)	3 (50)	6	0.925	
	Nurse	36 (48)	39 (52)	75	Reference	
	Sanitary Staff	7 (50)	7 (50)	14	0.891	
Health Facilities	C.H.C (Community health center)	22 (84.6)	4 (15.4)	26	0.05*	8.974 (2.679-30.056)
	P.H.C (Primary Health Center)	30 (65.2)	16 (34.8)	46	0.009*	3.059 (1.330-7.038)
	Sub- Center	19 (38)	31 (62)	50	Reference	

Table 54: Shows that a significant association was found between education level and practice regarding handling rule of biomedical waste management. Practice regarding handling rule was six time better 6.045 (1.883-19.411) in graduate and 6.33 (1.308-30.661) in post graduate than diploma holders.

Doctors had thirteen time better 13.542 (2.992- 61.289) practice of handling rule in biomedical waste management than nurses.

Practice was eight times better 8.974 (2.679-30.056) among the CHC staff and three times higher 3.059 (1.330-7.038) among PHC staff than sub-centre staff.

Table 55: Practice regarding Hazard of Health care workers in Biomedical waste management.

Variable	Category	**Practice regarding Hazard of BMWM**		Total (100%)	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	23 (88.5)	03 (11.5)	26	0.013*	5.023 (1.410-17.90)
	Female	58 (60.4)	38 (36.6)	96	Reference	
Education	10th Pass	6 (60)	4 (40)	10	0.763	
	12th Pass	2 (66.7)	1 (33.3)	3	0.691	
	Diploma	39 (54.9)	32 (45.1)	71	Reference	
	Graduate	21 (84)	4 (16)	25	0.014*	4.308 (1.34-13.837)
	Post Graduate	13 (100)	0(0)	13	0.998	
Occupation	Doctor	26 (96.3)	1 (3.7)	27	0.004*	20.429 (2.633-158.477)
	Lab Technician	4 (66.7)	2 (33.3)	6	0.614	
	Nurse	42 (56)	33 (44)	75	Reference	
	Sanitary Staff	9 (64.3)	5 (35.7)	14	0.566	
Health Facilities	C.H.C (Community health center)	24 (92.3)	2 (7.7)	26	0.001*	13.0 (2.772-60.975)
	P.H.C (Primary Health Center)	33 (71.7)	13 (28.3)	46	0.019*	2.750 (1.177-6.423)
	Sub- Center	24 (48)	26 (52)	50	Reference	

Table 55: Shows that significant association was found between practice regarding hazard in biomedical waste and gender. Practice regarding hazard was five times better 5.023 (1.410-17.90) in males than females. A significant association was found between education level and practice regarding hazard of biomedical waste management. Practice regarding hazard was four time better 4.308 (1.34-13.837) in graduate than diploma holders.

Doctors had twenty time 20.42 (2.633-158.477) better practice regarding hazard in biomedical waste management than nurses.

Practice regarding hazard was thirteen times better 13.0 (2.772-60.975)) among the CHC staff and almost three times higher 2.750 (1.177-6.423) among PHC staff than sub-centre staff.

Table 56: Practice regarding Precautionary Measure of Health care workers regarding Biomedical waste management.

Variable	Category	**Practice regarding Precautionary Measure of BMWM**		Total (100%)	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	19 (73.1)	7 (26.9)	26	0.105	
	Female	53 (55.2)	43 (44.8)	96	Reference	
Education	10th Pass	5 (50)	5 (50)	10	0.835	
	12th Pass	2 66.7)	1(33.3)	3	0.504	
	Diploma	33 (46.5)	38 (53.5)	71	Reference	
	Graduate	21 (84)	4 (16)	25	0.003*	6.045 (1.883-19.411)
	Post Graduate	11 (84.6)	2 (15.4)	13	0.022*	6.33 (1.308-30.661)
Occupation	Doctor	25 (92.6)	2(7.4)	27	0.001*	13.542 (2.992-61.289)
	Lab Technician	3 (50)	3 (50)	6	0.925	
	Nurse	36 (48)	39 (52)	75	Reference	
	Sanitary Staff	8 (51.7)	6 (42.9)	14	0.531	
Health Facilities	C.H.C (Community health center)	24 (92.3)	2 (7.7)	26	<0.05*	12.509 (3.302-47.380)
	P.H.C (Primary Health Center)	33 (71.7)	13 (28.3)	46	0.009*	3.059 (1.330-7.038)
	Sub- Center	24 (48)	26 (52)	50	Reference	

Table 56: Shows a significant association was found between education level and practice regarding precautionary measure of biomedical waste management. Practice regarding precautionary measure was six time better 6.045 (1.883-19.411) in graduate and 6.33 (1.308-30.661) time better in post graduate than diploma holders.

Doctors had thirteen time 13.542 (2.992-61.289) better practice regarding precautionary measure in biomedical waste management than nurses.

Practice regarding precautionary measure was twelve times better 12.509 (3.302-47.380) among the CHC staff and three times higher 3.059 (1.330- 7.038) among PHC staff than sub-centre staff.

Table 57: Total Practice of Health care workers regarding Biomedical waste management.

Variable	Category	**Total Practice of BMWM**		Total (100%)	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	15 (57.7)	11 (42.3)	26	0.431	
	Female	47 (49)	49 (51)	96	Reference	
Education	10th Pass	4 (40)	6 (60)	10	0.904	
	12th Pass	1 (33.3)	2 (66.7)	3	0.87	
	Diploma	27 (38)	44 (62)	71	Reference	
	Graduate	19 (76)	6 (24)	25	0.002*	5.160 (1.832-14.533)
	Post Graduate	11 (84.6)	2 (15.4)	13	0.007*	8.963 (1.844-43.558)
Occupation	Doctor	23 (85.2)	4 (14.8)	27	0.000*	8.161 (2.566-25.956)
	Lab Technician	3 (50)	3 (50)	6	0.68	
	Nurse	31 (41.3)	44 (58.7)	75	Reference	
	Sanitary Staff	5 (35.7)	9 (64.3)	14	0.695	
Health Facilities	C.H.C (Community health center)	22 (84.6)	4 (15.4)	26	0.05*	12.833 (3.770-43.690)
	P.H.C (Primary Health Center)	25 (54.3)	21 (45.7)	46	0.017*	2.778 (1.201-6.422)
	Sub- Center	15 (30)	35 (70)	50	Reference	

Table 57: Shows that a significant association was found between education level and total practice of biomedical waste management. Total practice was five times better 5.160 (1.832-14.533) in graduate and 8.963 (1.844-43.558) in post graduate than diploma holders.

Doctors had eight time higher 8.161 (2.566-25.956) total practice of biomedical waste management than nurses.

Total practice was twelve times better 12.833 (3.770-43.690) among the CHC staff and almost three times better 2.778 (1.201-6.422) among PHC staff than sub-centre staff.

No significant association was found between general knowledge regarding biomedical waste and gender.

Table 58: Knowledge of health care worker with respect to COVID19 in biomedical waste management.

Variable	Category	**Knowledge with COVID19 of BMWM**		Total (100%)	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	14 (53.8)	12 (46.2)	26	0.23	
	Female	64 (66.7)	32 (33.3)	96	Reference	
Education	10th Pass	2 (20)	8 (80)	10	0.019*	0.144 (0.029-0.732)
	12th Pass	0 (0)	3 (100)	3	0.999	
	Diploma	45 (63.4)	26 (36.6)	71	Reference	
	Graduate	20 (80)	5 (20)	25	0.133	
	Post Graduate	11 (84.60	2 (15.4)	13	0.152	
Occupation	Doctor	22 (81.5)	5 (18.5)	27	0.1	
	Lab Technician	5 (83.6)	1 (16.7)	6	0.357	
	Nurse	48 (64)	27 (36)	75	Reference	
	Sanitary Staff	3 (21.4)	11 (78.6)	14	0.007*	0.153 (0.039-0.598)
Health Facilities	C.H.C (Community health center)	20 (76.9)	6 (23.1)	26	0.145	
	P.H.C (Primary Health Center)	28 (60.9)	18 (39.1)	46	0.931	
	Sub- Center	30 (60)	20 (40)	50	Reference	

Table 58: Shows that a significant association was found between education level and occupation with Knowledge of COVID 19 of biomedical waste management. The odds of this knowledge being good in 10^{th} pass healthcare workers were lower 0.144 (0.029-0.732) the diploma holders. Secondly, the sanitary staff workers had less chances 0.153 (0.039-0.598) of possessing good knowledge compared to nurses.

Table 59: Practice of health care worker with respect to COVID19 in biomedical waste management.

Variable	Category	**Practice with COVID19 of BMWM**		Total (100%)	p value	OR (CI)
		Good (%)	Bad (%)			
Gender	Male	17 (65.4)	9 (34.6)	26	0.167	
	Female	48(50)	48(50)	96	Reference	
Education	10th Pass	3 (30)	7 (70)	10	0.374	
	12th Pass	1 (33.3)	2 (66.7)	3	0.691	
	Diploma	32 (45.1)	39 (54.9)	71	Reference	
	Graduate	19 (76)	6 (24)	25	0.010*	3.859 (1.378-10.811)
	Post Graduate	10 (76.9)	3 (23.1)	13	0.045*	4.062 (1.030-16.024)
Occupation	Doctor	21 (77.8)	6 (22.2)	27	0.013*	3.595 (1.304-9.908)
	Lab Technician	3 (50)	3 (50)	6	0.975	
	Nurse	37 (49.3)	38 (50.7)	75	Reference	
	Sanitary Staff	4 (28.6)	10 (71.4)	14	0.161	
Health Facilities	C.H.C (Community health center)	21 (80.8)	5 (19.2)	26	0.008*	4.440 (1.482-13.974)
	P.H.C (Primary Health Center)	20 (43.5)	26 (56.5)	46	0.657	
	Sub- Center	24 (48)	26 (52)	50	Reference	

Table 59: Shows that a significant association was found between education level, occupation and health facilities and practices of COVID-19 waste management. The practices were three times better 3.859 (1.378-10.811) in graduate and four times 4.062 (1.030-16.024) in post graduate than diploma holders.

Doctors had three time better 3.595 (1.304-9.908) practice of COVID-19 biomedical waste management than nurses.

Similarly, the CHC's COVID 19 biomedical waste management practices were more than four time 4.440 (1.482-13.974) better than sub centers

Table 60: Knowledge and corresponding practices of health care workers regarding biomedical waste.

Knowledge Category	**Percentage**	**Practice Category**	**Percentage**
a) General knowledge regarding BMWM	51.6%	a) General practice regarding BMWM	54.9%
b) Knowledge regarding Precautionary measures BMWM	82.7%	b) Practice regarding precautionary measures	59.1%
c) Knowledge regarding handling rules	68.3%	c) Practices regarding Handling rule	58.1%
d) Knowledge regarding bio-hazards	57.3%	d) Practice against bio-hazards	66.3%
Total Knowledge	**62.2%**	**Total Practice**	**50.8%**

Table 60: Shows that despite having good knowledge (82.7% and 68.3% respectively) regarding Precautionary measures and handling rules, the practices being followed by participants were poor (59.1% and 58.1% respectively).

In contrast to above findings, there was poor general knowledge regarding bio medical waste and poor knowledge regarding their hazards (51.6% and 57.3%), despite having better practices corresponding to both of these parameters (54.9% and 66.3% respectively).

On the whole, the knowledge of the health care workers was a tad bit better (62.2%) than the practices followed (50.8%) by them.

Table 61: Poor practices of health care workers with corresponding good knowledge regarding handling of Biomedical Waste.

Good Knowledge Category	**Percentage**	**Poor Practice Category**	**Percentage**
a) Good General knowledge regarding BMWM	51.6%	a) Poor General practice regarding BMWM	22.9%
b) Good Knowledge regarding Precautionary measures BMWM	82.7%	b) Poor Practice regarding precautionary measures	32.7%
c) Good Knowledge regarding handling rules	68.3%	c) Poor Practices regarding Handling rule	22.9%
d) Good Knowledge regarding bio-hazards	57.3%	d) Poor Practice against bio-hazards	12.2%
Total Good Knowledge	**62.2%**	**Total Poor Practice**	**22.9%**

Table 61: Shows that there 51.6 % of the health care workers with good general biomedical waste management but 22.9% among them had poor practices.

Similarly, the study subject having good knowledge regarding precautionary measure were 82.7% but 32.7% of them were poorly practicing the precautionary measures while handling the biomedical waste.

Talking about biomedical waste handling rules 68.3% had good knowledge but 22.9% were following poor handling practices.

More than half of the health care workers (57.3%) had good knowledge regarding bio-hazards but about one-tenth (12.2%) had poor practicing against the bio-hazards of the biomedical waste.

Overall, this table show that, 62.2% of the health care workers were having good knowledge but among them 22.9% were having poor practice.

Table 62: Good practices of health care workers with corresponding poor knowledge regarding handling of Biomedical Waste.

Poor Knowledge Category	**Percentage**	**Good Practice Category**	**Percentage**
a) Poor General knowledge regarding BMWM	48.3%	a) Good General practice regarding BMWM	21.3%
b) Poor Knowledge regarding Precautionary measures BMWM	17.2%	b) Good Practice regarding precautionary measures	09.1%
c) Poor Knowledge regarding handling rules	31.9%	c) Good Practices regarding Handling rule	04.9%
d) Poor Knowledge regarding bio-hazards	46.6%	d) Good Practice against bio-hazards	21.3%
Total Poor Knowledge	**37.7%**	**Total Good Practice**	**11.4%**

Table 62: Shows that the health care worker who were having poor general biomedical waste management knowledge 48.3 but still 21.3% among them had good practices.

The study subject having poor knowledge regarding precautionary measure were 17.2% but 09.1% of them were practicing the precautionary measures well, while handling the biomedical waste.

Talking about biomedical waste handling rules 31.9% had poor knowledge but 04.9% were following good handling practices among them.

Nearly half of the health care workers (46.6%) had poor knowledge regarding bio-hazards but about one-fifth (21.3%) had good practicing against the bio-hazards of the biomedical waste.

Overall, this table revealed that, 37.7% of the health care workers have poor knowledge but 11.4% of them were following good practice.

Table 63: Correlation between score of knowledge and practice

BMWM Category	Correlation	P- value
General knowledge with General practice.	0.014	0.911
Knowledge of handling rule with Practice of Handling rule	0.338	00.007*
Knowledge of hazard with Practice of Hazards	0.276	0.029*
Knowledge of precautionary measure with Practice of precautionary measure	-0.051	0.694
Total Knowledge with Total practice	0.134	0.295
*Correlation is significant if P <0.05		

Table 63: Shows that there was a week positive correlation between knowledge of biomedical waste handling rule with practice of biomedical waste handling rule. (r=0.338, p=0.007) was found. Knowledge regarding biomedical waste hazards with practice was found to be correlated (r=0.276, p=0.029). This signifies that good knowledge, signifies better practice.

This study also revealed that the knowledge of precautionary measures was inversely co related (r= -0.051) with its practice. However, it was not found to be significantly correlated (p=0.694).

Result and Discussion

RESULT AND DISCUSSION

The present study entitled "A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad" was carried out in health care facilities of rural area of Ghaziabad city. The results of the study are discussed as follows:

Socio-Demographic Profile of the Health care workers

In the present study, 26 (21.3%) health care workers were from CHC, 46 (37.7%) were from PHC and 50 (41%) were from sub-centre. (Table 1). There were 27 (22.1%) doctors,18 (66.6%) from CHC and 9 (33.3%) from PHC. Out of the 75 (61.4%) nurses selected, 50 (66.6%) belonged to the sub centre, 21 (28.0%) from PHC and 4 (5.3%) from CHC. One lab technician (16.6%) was from CHC and the remaining 5 (83.3) from PHC. Among the 14 (11.4%) sanitary staff, 11 (78.5%) were from PHC and 3 (27.2%) from CHC. (Table 2)

Majority of the study participants in the present study were female 96 (78.6) and 26 (21.3%) were male. A cross-sectional study conducted by Saha A et.al in the year 2019 in Tripura, where majority of the study participants (65.4%) was female[81] (Figure 1)

In current study, maximum number of the study participants 61 (50.0%) were in the age group of 31-40, followed by 41-50 years (30.3 %). There were 17 (13.9%) subjects` of the age 21-30 years and 7 (5.7%) in the age group of 51 and above years respectively. Similar result was found in a study conducted by a Kamakar N et al in the year 2016 in Agartala, where maximum number (74.2%) of health care worker were from 20-30-year age group.[82] (Figure2)

In this study most (58.2%) of the health care workers were diploma holders followed by 25 (20.5%) graduates and 13 (10.7%) were post graduates. Also 10 (8.2%) had studied till 10^{th} and 3 (2.5%) up to 12^{th} respectively. Similar result was found in a cross sectional study in Haryana conducted by Singh S at el in 2020, where maximum number of health care workers were diploma holders (47.6%).[83] (Figure3)

Knowledge of the Health care workers.

In the present study,111(91.0%) of the health care workers were aware of the term Biomedical waste management and 11 (9.0%) were unaware. In this study only 13 (10.7%) of the health care workers were unaware of "Biomedical waste management & handling rule" and 109 (89.3%) were aware of handling rule. In a study conducted by Haque et al in Bihar in the year 2021, the author observed that 22 (18%) of the health care workers were unaware regarding biomedical waste and handling rules.[84] (Table 3)

The current study showed that only 42 (34.5%) of the health care workers knew that the rules of bio medical waste management were first introduced in 1998 which comprises of half of the doctors 14 (51.9%), two third of the lab technicians 4 (66.7%), about one fourth of the nurses 22 (29.3%) and only 2 (14.3%) of the sanitary staff. (Table 4)
Regarding the revision of biomedical waste rules and regulations, this study has found that 16 (59.3%) doctors, half of the lab technicians 3 (50%), almost one fifth of the nurses 24 (19.7%) and about one fourth 4 (28.6%) of the sanitary staff knew correctly that the Bio medical waste management and handling rules were revised in 2016.Knowledge regarding the same was found in one fourth 31 (25.8%) of the subjects in the study conducted by Haque et al[84]. Likewise, Ananthachari KR at el in kerala in the year 2016, found that 42.8% (243) knew about the Bio medical waste management and handling rules [86] (Table 5)

In this study awareness regarding different colour coding for segregation of the Biomedical waste, was best among the sanitary staff 14 (100%) followed by the nurses 73 (97.3%), doctors 26 (96.3%) and lab technicians 5 (83.3%) respectively who were aware about the correct colour coding for segregation. Amin PP[79] et al in the year 2018 in Gujarat, found that, doctors (94%) had the best knowledge regarding different colour coding followed by paramedic staff (85%). (Table 6)

In the present study total of 73 (59.8%) health care workers knew about the correct agency that regulate biomedical waste which included 6 (100%) lab technician, 18 (66.7%) of the doctors, 46 (61.3%) nurses and 3 (21.4%) of the sanitary staff workers.

The knowledge regarding the correct agency was known by 80 (66.7%) of the study subjects as quoted by Haque et al in Bihar in the year 2021.[84] (Table 7).

This study revealed that 115 (94.3%) of the health care workers were aware of biomedical waste hazards which comprised of all of the doctors 27 (100%), 6 lab technicians (100%), 71 (94.7%) nurses and 11 (78.6%) of the sanitary staff. (Table 8).

Diseases like Hepatitis and HIV/AIDS may be caused by improper disposal of bio-medical waste, participants having this knowledge were all of the 6 (100%) lab technicians, 26 (96.3%) doctors, 64 (85.3%) nurses and 6 (42.9%) sanitary staff. Letho Z et al in the year 2021 found that participants had good knowledge regarding the spread of these two diseases (83.5% and 88.2%) in the study conducted in Bhutan.Ananthachari KR et al. in kerala in the year 2016 found that a total of 89.6% of health care workers said that the infections like HIV, hepatitis B and hepatitis C could be transmitted during collection, segregation, transportation and treatment of biomedical waste management.[86] (Table 9)

All the doctors (100%), Lab technicians 6 (100%) and Nurses 75 (100%) while 13 (92.9%) of the sanitary staff were aware of the precautionary measure to be taken while handling biomedical waste. (Table 10)

Among the doctors 26 (96.3%), 24 (88.9%), 22 (81.5%) and 22 (81.5%) respectively know that gloves, mask, goggle and PPE are the precautions to be taken while handling biomedical waste.

In case of sanitary staff workers, the result was 14(100%), 9 (64.3%), 5 (35.7%) and 5 (35.7%), while in case of nurses it was 75 (100%), 59 (92%), 54 (72%) and 63 (84%) for gloves, mask, goggles and PPE kit respectively. (Table 11)

All of the doctors 27 (100%), lab technicians 6 (100%) and Nurses 75 (100%) and 12 (85.7%) sanitary staff in the current study knew that wearing a PPE kit could reduce the risk of infection. Deress T et al in Euthopia, in the year 2019 found that 94.5% of HCW believed that wearing PPE kit could reduce the risk of infection[87], while Letho Z et al. in

the year 2021, observed that 98.2% of the healthcare workers had good knowledge regarding PPE kit.[85] Both these studies substantiated this study. (Table 12)

In the present study knowledge regarding reporting of any hazardous event within 24 hours while handling BWM was found in 13 (48.1%) doctors, 2 (33.3%) lab technicians, 22 (29.3%) nurses and 3 (21.4%) sanitary staff worker. Amin PP at el in the year 2018 in Gujarat, found that most of the health care workers (91.7%) having a needle stick injury while handling BMW immediately reported it. This included all the doctors and most of the paramedical staff (82%), in their study.[79] (Table 13)

In the present study, doctors 13 (48.1%) have most and sanitary staff 3 (21.4%) have the least knowledge of correct thickness of plastic sheet provided inside different bins. Among the lab technician, 4 (66.7%) and 20 (26.7%) of nurses knew that 50mm is the correct thickness of the plastic sheets. (Table 14)

In the current observational study, only a meagre 7 (5.7%) study participants were correctly aware that BMW should not be kept for more than 48 hours, followed by 12 hours 42 (34.4%), 24 hours 67 (54.9%) and 72 hours 6 (4.9%) respectively. Similarly, Deress T et al. in Ethiopia in the year 2019, found that only 12.7% of the health care workers correctly identified that maximum time period for keeping the BMW was 48 hours.[87] However, this knowledge was found higher (37.6%) in a study done by Letho Z et al in the year 2021 in Bhutan and Ananthachari KR at el in the year 2016 in Kerala, where 44.3% of the participants correctly knew the maximum time for storing the biomedical waste.[85,86] Amin PP et al also concluded that 54% of the study subjects were aware that the bio medical waste must not be kept for more than 48 hours as per Biomedical Waste (Management and Handling) Rules, 1998.[79] The last two studies being conducted in high literacy states (Gujarat & Kerala respectively), could be the reason for better knowledge. (Table 15)

Out of total 122 health care workers, nearly half (48.4%) knew that pretreated vacutainer was handed over in Red category waste whereas 5 (4.1%), 34 (27.9%) and 24 (19.7%) said the colour category to be Black, Blue, and Yellow respectively.

Further 10 (37.0%) of the doctors 4 (66.7%) of the lab technicians, 9 (64.3%) of the sanitary staff and 36 (48.0%) of nurses correctly answered the colour category. (Table 16)

In the present study, more than three fourth of health care workers (77%) in the present study knew that the general waste should not be collected in yellow colour coded bins. Among those who didn't know, 8 (29.6%) were doctors, 1 was (16.7%) lab technician, 17 (22.7%) were nurses and 2 (14.3%) were sanitary staff workers. A close finding was reported by Deress T et al. in Ethiopia in the year 2019, who had identified that 72.7% study participants knew that the general waste should be disposed off in a black coloured container.[87] Noticeably, a contrasting result was reported by Ananthachari KR et al in Kerala, where majority of HCW (88.5 %) did not have the correct knowledge regarding waste disposal in appropriate bin.[86] (Table 17).

In the present study, 22 (81.5%) of the doctors, 5 (83.3%) of lab technicians, 56 (74.7%) of the nurses and 11 (78.6%) of the sanitary staff workers, said correctly that segregation is most important aspect of biomedical waste management. Similarly, Haque et al in Bihar in the year 2021 said that 93.3% (112 out of 120) HCW had good knowledge of segregation being the crucial part of biomedical waste management.[84] Similar finding of 77% knowledge among sanitary staff, was observed by Basavaraj TJ et al in Bangalore in the year 2021, regarding segregation of waste.[88] (Table 18).

In the current study, total 51 (41.8%) health care workers knew that incineration is the treatment for yellow bags, 17 (63.0%) were doctors, 6 (100%) were lab technicians, 26 (34.7%) were nurses and 2 (14.3%) were sanitary staff workers. (Table 19)

Laboratory waste is most infectious waste. It should be pretreated on site before sending for the final disposal. This was correctly identified by 53 (43.4%) health care workers in the present study. Pullishery F et al noticed that pre-treatment of the infectious lab waste was done by 46% of the health care workers[89], this was similar to our study. In a study performed by Amin PP et al in surendranagar in the 2018, the author observed that 9 out of 10 doctors said that waste which was infectious should be disinfected before shredding and final disposal.[79] (Table 20).

In the present study correct symbol for Biohazard was identified by 59.8% of the total health care workers. In contrast to this, in a study conducted by Deress T et al. in Ethiopia 34.5% of the HCW correctly identified the symbol of Biohazard.[87] While in a study conducted by Basavaraj TJ et al in Bangalore, 100% participants correctly identified the Biohazard symbols.[88] (Figure 5)

In the current study, about half of the health care workers 66 (54.1%) correctly knew how to prepare 1L of "1% Sodium hypochlorite from available 5% strength" which constituted 21 (77.8%) doctors, 4 (66.7%) lab technicians, 38 (50.7%) nurses and only 3 (21.4%) of sanitary staff. This was similar to the finding of Basavaraj TJ et al in Bangalore in the year 2021, where 86.7% of the doctors knew how to correctly prepare the disinfectant.[88] (Table 21).

In the present study 101 (82.78%) of health care workers could not match the different colour coding, as per the revised 2016 biomedical waste management and handling rule. Among the total HCWs, only 21 (17.2%) health care workers were able to match the correct colour. Similar results were observed by FawazPullishery et al in Mangalore in the year 2016, where 21.6% health care worker were able to identify the colour code correctly.[89] (Table 22)

The present study revealed that only 36.1% of the health care workers (25% of doctors, 6.8 % of lab technicians, 63.6 % nurses and 4.5 % of the sanitary staff workers) knew that pollution control board of India regulates the waste generation and safe transportation of the biomedical waste. Ananthachari KR et al in kerala, found that 73.8% knew that pollution control board regulate biomedical waste management and handling practices, of which 29.9 % nursing staffs, 17.8% doctors and 8.2% were lab technicians.[86]Haque et al in Bihar in the year 2021, found that 66.7% of the health care workers knew about the transport agency that regulates the waste generated at health care facility.[84] It was lower in this study may be because of the lower educational status of study participants. (Table 23)

Practice of the Health care workers.

In the present study 98 (80.3%) of the health care workers said that they were practicing biomedical waste management properly in their setup. Regrettably, 23 (18.9%) of the health care worker said that the revised biomedical waste management rules were not followed in their setup. All of the doctors 27 (100%) and lab technician 6 (100%), while 62 (82.7%) nurses and 8 (57.1%) sanitary workers, were following the correct color coding of the revised BMW. Correct segregation of BMW, was followed by all of the doctors 27 (100%) and lab technicians 6 (100%) and only 58 (77.3%) of nurses and 11 (78.6 %) of sanitary staff.. Similar results were found by Jalal SM et al.in Saudi Arabia in the year 2021, where most of the HCWs 79.3%, were following the ministry of health guidelines. Majority of the HCW (69.1%) correctly practiced the disposal of bio medical waste in the coloured bins.[90] (Table 24)

The health care worker correctly following the new colour coding since 2016 were 11 (9%) constituting 10 (37%) doctors, 4 (66.7%) lab technicians, 36 (48%) nurses and 3 (21.4%) sanitary staff. (Table 25)

In the current study the correct practice regarding collection and segregation was found in 97 (79.5%) of the health care workers, as they knew that the biomedical waste is to be segregated in different colour coded bags, which was better than a study conducted by Saha A et.al in the year 2019 in Tripura, who observed that only 23.3% of HCW were segregating the biomedical waste into specific coloured bins at the point of generation.[81] (Table 26)

In this study, 25 (92.6%) doctors 5 (83.3%) lab technicians, 47 (62.7%) nurses and 7 (50%) sanitary staff workers, were labelling the hazardous waste separately. Similar practice was seen by Amin PP et al in the year 2018 in Gujarat, found that all doctors and most of the paramedical staff (87%) were labelling the hazardous bin before filling, as they felt it was very crucial aspect of biomedical waste management.[79] Comparatively lower practice of labelling the infectious waste (29.94%) was found by Pullishery F et al.in Mangalore in the year 2016.[89] (Table 27)

In the present study puncture proof containers for sharp waste were used by 88 (72.1%) of the HCW which comprises of 25 (92.6%) doctors, 6 (100%) lab technicians, 50 (66.7%) nurses and 7 (50%) sanitary staff. Likewise, Amin PP [4] et al in the year 2018 in Gujarat, found that around 3/4th (75.3%) of the participants dispose off the sharps in white puncture proof container.[79]Deress T et al. in Ethiopia, observed that most (93%) HCFs used puncture resistant containers to store hazardous wastes temporarily, implying the need to improve the precautionary practices among health care workers of our study area.[87] (Table 27).

In this study, the precautionary practices were considerably better (71.3%) than a study conducted by Basavaraj TJ et al in Bangalore in the year 2021, where sanitary Staff were not wearing PPE while the nurses and doctors were wearing PPE most of the time[88] (Table 27).

In the current study, 105 (86.2%) of health care workers were storing the biomedical waste for not more than 48 hours except 15 (20%) nurses and 1 (3.7%) doctor. All the lab. technicians were following the correct time limit for storage of BMW. Basavaraj TJ et al in Bangalore in the year 2021, observed that 91.07% of the doctors and 16.82% of the nurses were following the correct practice of storing biomedical waste not more than 48 hours.[88] (Table 28).

In this study, one third (33.6%) health care workers were using appropriate plastic sheets of 50mm for the biomedical waste management. Of them 14 (51.9%) were doctors, 4(66.7%) were lab technicians, 21 (28%) were nurses and 2 (14.3%) were sanitary staff workers (Table 29).

In the present study most of the doctors (85.2%) were practicing a system of reporting injuries and accidents due to BMW. Basavaraj TJ et al in Bangalore in the year 2021, also observed that majority of the doctors and nurses were in a habit of reporting injuries and accidents.[88] Precautionary practice of the sanitary workers was found to be satisfactory (71.4%) as compared to previous study (50%). In the study conducted by Amin PP et al, the doctors had a system for reporting the incidence of any hazardous event[79](Table 30).

In this study, a system of reporting needle stick injuries within 24 hours was being practiced by 86 (70.4%) health care workers. Amin PP et al in the year 2018 in Gujarat, observed that majority of health care workers (91.7%) believed that needle-stick injuries should be reported immediately[79](Table 31).

In the present study 99 (81.1%) of the HCW were immunized against Hepatitis B, which is comparatively higher than the findings of Saha A et.al in the year 2019 in Tripura, where only 66.17% were immunized against hepatitis B.[81] (Table 32).

In Current study, 101 (82.8%) of the health care workers were following Post Exposure Prophylaxis. Mehta TK et al.in the western India in the year 2018, found that 42.46% doctors and only 15.9% nurses were following post exposure prophylaxis (PEP).[91]Basavaraj TJ et al in Bangalore in the year 2021, observed that practice of the following PEP after needle stick injury was lowest among sanitary staff. While in our study, doctors and nurses were following PEP the most[88] (Table 32).

In the current study 34 (27.9%) of the health care workers were throwing the infectious waste in black container. Basavaraj TJ et al in Bangalore in the year 2021, found that all of doctors, sanitary staff and 87.5% of the nurses were in a good habit of putting non-infectious waste in black container.[88] (Table 32).

In the present study, 35 (28.7%) of the health care workers knew the correct preparation of 1% of Sodium hypochlorite. This included 48.1% doctors, 16.7% lab technician, 26.7% nurses and 7.1% sanitary staff workers. Similar practice was seen among 42.46% doctors and 40.6% of the nurses in a study conducted Mehta TK et al.in the western India.[91] (Table 33).

In the current study, majority of the health care workers 86 (70.5%) were following a good practice of maintaining a register in the present study. In a study conducted by Saha A et.al in the year 2019 in Tripura, the author observed that no proper record was maintained by any health care workers.[81] (Table 34)

In this study, 32% of the health care workers said that a private agency is assigned for safe transport of biomedical waste, 47.5 % said that a state agency is responsible and

13.1% were not aware of any such responsibility in this study. Amin PPet al in the year 2018 in Gujarat, found that 58% health care workers stated a private agency was transporting the BMW, 29% stated government agency was responsible for transport while 13% were unaware.[79](Table 35).

In present study 96.7% of the HCW were using gloves and 88.9% of our health care workers were wearing PPE. Bit similar finding was seen in Deress T et al. in Ethiopia in the year 2019, where 44 (80.0%) of the study participants were using heavy-duty gloves while 48 (87.3%) were using protective apron.[87] (Table 36)

Associated factors with respect to COVID-19

Central Pollution Control Board (CPCB) of India brought out specific guidelines for the handling, treatment, and disposal of waste generated during treatment, diagnosis, and quarantine of COVID-19 patients on March 18, 2020. These guidelines were revised on July 17, 2020.[92]

In the present study 13 (48.1%) doctors, 3 (50%) lab technicians, 22 (29.3%) nurses and 4 (28.6%) sanitary staff workers, knew that goggle, face shield and gloves used in COVID 19 are to be disposed in red bins. Unfortunately, 54 (44.3%) and 14 (11.5%) were wrongly throwing them in yellow and black bins respectively. Moreover 12 (9.8%) of the health care workers did not know correct method of disposal of COVID 19 protective gear. In Comprehensive Review of the National and International guidelines done by Capoor MR et al. in the year 2021, the author enlightens us that the face shields, goggle, and gloves used for COVID 19 patients should be collected in red bags[93] (Table 37).

In current study, 11 (40.7%) doctors, 2 (33.3%) lab technicians, 39 (52%) nurses and 6 (42.9%) sanitary staff workers, were correctly disposing the COVID-19 infected N-95 mask in yellow bin. Unfortunately, 31 (25.4%) and 20 (16.4%) were wrongly disposing them in red and black bins respectively. Moreover 13 (10.7%) of the health care worker did not know correct method of disposal of used COVID-19 protective equipment. Used (N-95) masks of COVID-19 patients, blood- or body fluid–contaminated swabs should be treated as BMW. They should be collected in non-chlorinated yellow bags, according to comprehensive review conducted by Capoor MR et al. in the year 2021.[93] (Table 38)

In the present study, 71 (58.2%) of the total health care workers were aware of the use of double layered bags for collection of COVID-19 waste. Importantly, 23 (18.9%) of the participants were unaware of any such practices. Capoor MR et al in the year 2021, found that the Indian guidelines prefer the use of double-layered bags for collection and transport of COVID-19 infected waste to prevent spillage or leaking[93] (Table 39).

In the current study, 77 (63.1%) of the health care workers were disposing off the COVID-19 waste in 12 hours and 26 (21.3%) were disposing in 24 hours respectively, which is the correct time to dispose the COVID-19 waste. The wrong knowledge of disposing in 48 hours was reported by 4 (3.3%) and a still higher number 15 (12.3%) of health care workers were unaware about the correct method. (Table 40)

In the present study, only 40 (32.8%) health workers knew correctly that the used plastic overalls (hezmet suits) should be disposed off in red bins. This is according to the comprehensive review of the study done by Capoor MR et al in the year 2021, stating that the PPE kit and hezmet suits should be collected in red bags[93](Table 41).

In the present study more than half 71 (58.2%) of the health care workers correctly knew that the inner and the outer surface of biomedical waste container from COVID-19 must be disinfected daily with 1 % Sodium Hypochlorite. For disinfection of biomedical waste management (BMWM) articles, freshly prepared 1% sodium hypochlorite is recommended by the Indian guidelines, as seen by the author Capoor MR et al in comprehensive review[93] (Table 42).

In this study most of the doctors (92.6%) and all (100%) of the lab. technicians knew about this mandate. However, level of awareness was less among nurses (9.3%) and sanitary staff workers (35.7%). Central Pollution Control Board (CPCB) of India brought out specific guidelines for COVID-19 waste, in the March 18, 2020. These guidelines state that BMW containers should have a separate COVID-19 labeled waste bin[92] (Table 43).

In this study, COVID 19 BMW is the name of the application developed by the state pollution control board was known by only 29 (23.8%) of the health care workers and most of them (46.7%) were unware about it. (Table 44)

Deep burial was the preferred method for disposing COVID 19 waste from remote quarantine centre for 52.5% of the study subjects. Similar findings were corroborated by Saha A et.al in the year 2019 in Tripura, where they reported that deep burial was the

preferred mode of disposal in hospitals situated in remote areas by 53.33% health care workers.[81] (Table 45)

The current study revealed that, overall, 86 (70.5%) of the healthcare workers were using separate colour-coded bins with foot operated lids for COVID 19 waste disposal, maximum doctors (92.6%) were complying with this mandate. Central Pollution Control Board (CPCB) of India in July 2020, has advised separate colour-coded bins with foot operated lids for Biomedical waste from COVID-19[92] (Table 46).

In the present study, a separate record was being maintained for COVID 19 waste by 67 (54.9%) of the health care workers which comprised of 17 (25.3%) doctors, 4 (5.9 %) lab technicians, 44 (65.6 %) nurses and 2 (2.9 %) sanitary staff. Jalal SM et al.in Saudi Arabia in the year 2021, found that 70.7% of the health care workers maintained separate records for COVID-19 BMW.[90]Basavaraj TJ et al in Bangalore in the year 2021, observed that a separate record for COVID 19 biomedical waste was maintained by 73.21% of the doctors, 87.5% of the nurses and 95.08% of the sanitary staff.[88] Above findings may be explained by the fact that the latter two studies were conducted in dedicated COVID-19 hospitals. Besides, relatively lower practice in our study could be explained by the fact that mostly the COVID care provided in our health facilities was limited to the diagnostic part only. (Table 46)

In present study, 61 (50%) of the total healthcare workers had not attended any government certified training of hospital waste management. Karmakar N at el in Tripura in the year 2016, found that only one-third 35.8% of health care staff had attended training session on BMW management.[82]Basavaraj TJ et al in Bangalore in the year 2021 observed that only 36.6% of the doctors and 14.75% of the sanitary staff had undergone any training in BMW management.[88](Table 47).

In the present study significant association was found between level of education and general knowledge of biomedical waste management. Knowledge of graduate was almost five times higher [4.863 (1.729-13-675)] than diploma holders. Doctors had three times higher [3.371 (1.310-8.675)] general knowledge regarding biomedical waste management than nurses.

General knowledge was almost five times higher [4.825 (1.703-13.671)] among the CHC staff and two times higher [2.311 (1.017-5.250)] among PHC staff than sub-centre staff (Table 48).

Similarly, Saha et al in northeast India in the year 2019, reported that health workers with higher technical degree, had fair knowledge of Health care waste management ($P < 0.05$). Overall, 37.68% of the health-care providers in the above study were found to have fair knowledge regarding the different aspects of health care waste management (HCWM).[81] (Table 48).

This study showed that 16 (61.5%) male and 67 (69.8%) female had good knowledge regarding handling rule of Biomedical waste management. Majority of HCW were doctors 19 (70.4%) followed by nurses 51 (68%), lab technicians 4 (66.7%) and sanitary staff workers 9 (64.3%). (Table 49)

This study showed that 20 (76.9%) male and 81(84.4%) female had good knowledge regarding precautionary measure of Biomedical waste management and maximum of them were nurses (85.3%) followed by lab technicians (83.3%), 81.5% doctors and sanitary staff workers 10 (71.4%) (Table 50).

The present study showed that 16 (68.5%) male and 54(56.3%) female had good knowledge regarding hazards of Biomedical waste management and maximum of them were doctors (74.1%) followed by lab technicians (66.7%), nurses 41 (54.7%) and sanitary staff workers 5 (35.7%) (Table 51).

The present study revealed a significant association between occupation and total knowledge of biomedical waste management. Knowledge of doctors had three times higher 3.274 (1.119-9.579) total knowledge of biomedical waste management than nurses. Total knowledge was five times higher 5.5 (1.655-18.278) among the CHC than sub-centre staff. (Table 52).

The present study showed a significant association between education level and general practice of biomedical waste management. General practice was four times better 4.086 (1.458-11.453) in graduate and 4.301 times (1.090-16.974) in post graduate than diploma holders. Doctors had five times better 5.029 (1.722-14.686) general practice of biomedical waste management than nurses. (Table 53).

In this study, a significant association was found between education level and practice regarding handling rule of biomedical waste management. Practice regarding handling rule was six times better 6.045 (1.883-19.411) in graduate and 6.33 (1.308-30.661) in post graduate than diploma holders. Doctors had thirteen times better 13.542 (2.992- 61.289) practice of handling rule in biomedical waste management than nurses. (Table 54)

The present study showed a significant association between practice regarding hazard in biomedical waste and gender. Practice regarding hazard was five times better 5.023 (1.410-17.90) in males than females. A significant association was found between education level and practice regarding hazard of biomedical waste management. Practice regarding hazard was four times better 4.308 (1.34-13.837) in graduate than diploma holders. Doctors had twenty times 20.42 (2.633-158.477) better practice regarding hazard in biomedical waste management than nurses. (Table 55)

In the present study practice of precautionary measures revealed that the practice was six [6.045 (1.883-19.411)] times higher among graduates and six [6.33 (1.308-30.661)] times higher among post graduates than diploma holders. Practice regarding precautionary measures was thirteen [13.542 (2.992-61.289)] times higher among doctors as compared to nurses. Mathur et al in the year 2011, had similar finding in which precautionary practice was significantly higher among health-care workers having higher technical qualifications.[94] (Table 56).

In present study, a significant association was found between education level and total practice of biomedical waste management. Total practice was five times better [5.160

(1.832-14.533)] in graduates and eight times [8.963 (1.844-43.558)] higher in post graduates than diploma holders. Doctors had eight times better [8.161 (2.566-25.956)] practice of biomedical waste management than nurses. Saha A et al. in Tripura, in the year 2019, found that the overall practice of waste management was better among the health-care providers with higher technical qualification ($P < 0.05$).[81] Similarly in current study, the total practice was twelve times better [12.833 (3.770-43.690)] among the CHC staff and almost three times better [2.778 (1.201-6.422)] among PHC staff than sub-centre staff. Saha et al. in Tripura, in the year 2019, also found that biomedical waste management practices were better among the in-service health care workers.[81](Table 57)

In the current study, knowledge of COVID 19 biomedical waste management shows that the odds of good knowledge among 10th pass healthcare workers were lower 0.144 (0.029-0.732) than diploma holders. Secondly, the sanitary staff workers had less chances 0.153 (0.039-0.598) of possessing good knowledge as compared to nurses. (Table 58).
In the present study, a significant association was found between education level, occupation and health facilities with practices of COVID-19 waste management. The practices were three times better 3.859 (1.378-10.811) in graduate and four times 4.062 (1.030-16.024) in post graduate than diploma holders. Doctors had more than three time better 3.595 (1.304-9.908) practice of COVID-19 biomedical waste management than nurses. Similarly, in the CHC's COVID 19 biomedical waste management practices were more than four times 4.440 (1.482-13.974) higher than sub centres (Table 59).

This study revealed that, despite having good knowledge (82.7% and 68.3% respectively) regarding Precautionary measures and handling rules, the practices being followed by participants were poor (59.1% and 58.1% respectively).
In contrast to above findings, there was poor general knowledge regarding bio medical waste and poor knowledge regarding their hazards (51.6% and 57.3%), despite having better practices corresponding to both of these parameters (54.9% and 66.3% respectively).

Overall, the knowledge of the health care workers was a tad bit better (62.2%) than the practices followed (50.8%) by them. (Table 60).

The present study revealed that, 62.2% of the health care workers were having good knowledge but among them 22.9% were having poor practice. (Table 61)

The present study revealed that, 37.7% of the health care workers have poor knowledge but 11.4% of them were following good practice. (Table 62)

In the present study, a week positive correlation between knowledge of biomedical waste handling rule with practice of biomedical waste handling rule. (r=0.338, p=0.007) was found. Knowledge regarding biomedical waste hazards with practice was found to be correlated (r=0.276, p=0.029). This signifies that good knowledge, signifies better practice.

This study also revealed that the knowledge of precautionary measures was inversely co related (r= -0.051) with its practice. However, it was not found to be significantly correlated (p=0.694). (Table 63)

Conclusion

CONCLUSION

Based on the findings of the study entitled "A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad" following conclusions were drawn:

The overall knowledge of health care worker regarding Bio medical waste management was found appropriate in two thirds of the health care workers, of which doctors had the maximum knowledge followed by lab technician, nurses and sanitary staff respectively. CHC health care workers had the highest knowledge regarding Bio medical waste management followed by PHC health care workers and sub-centers respectively.

Knowledge of Biomedical waste management was found to be highest for precautionary measures followed by knowledge for handling rules and bio-hazards respectively.

Appropriate practice of Bio medical waste management was found to be in fifty percentage of the health care workers, of which doctors were having the best practice followed by lab technician, nurses, and sanitary staff respectively. It was highest for bio-hazards practice followed by precautionary practice, handling rules practice and general practice respectively.

A significant association was found between education level with general knowledge and general practice of Bio medical waste management among healthcare workers. Knowledge of graduates was almost five times higher than diploma holders. Doctors had three times higher general knowledge than nurses. General practice was four times better in graduates as well as in post graduate than diploma holders. Doctors were found to have five-time better general practice of biomedical waste management than nurses.

A significant association was found between occupation and overall knowledge of biomedical waste management among the healthcare workers. Overall knowledge of doctors was three times higher than nurses.

Education level and overall practice of biomedical waste management was found to be significantly associated. Total practice was five times better in graduate and eight time better in post graduate than diploma holders.

Practice regarding handling rules of biomedical waste management was significantly associated with education level. It was six times better among graduates and post graduate than diploma holders. Doctors had thirteen-times better practice of handling rule in biomedical waste management than nurses.

A significant association was seen between education level with practice regarding hazards as well as precautionary measures of biomedical waste management. Practice regarding hazards was four times higher in graduate than diploma holders. Practice regarding precautionary measures was six times higher in graduate than diploma holders.

Practices of COVID-19 waste management were observed to be significantly associated with education. The practices were three times better in graduate and four times better in post graduate than diploma holders.

Practice of biomedical waste management of COVID-19 was significantly associated with occupation. Doctors had three times better practice than nurses.

A weak positive correlation was observed between knowledge with practice of biomedical waste handling rule and knowledge with practice of biomedical waste hazards. It shows that more knowledge, leads to better practice in both these instances.

Recommendation

RECOMMENDATIONS

- It is our fundamental right to live in clean and safe environment.
- Biomedical waste management should be shared teamwork with committed government backing.
- Health-care workers should adhere to good BMW practices.
- Continuous monitoring of BMW practices, and strong legislature should be applied.
- The pillar of BMW is segregation of waste at source.
- The current BMW 2016 rules are an improvement over earlier rules in terms of improved segregation, transportation, and disposal methods, to decrease environmental pollution and ensure the safety of the staff, patients, and public.
- It is recommended that there should be regular organizations of Biomedical waste training programs and all HCWs should compulsorily attend such programmes.
- It should be made compulsory for healthcare facilities to get their healthcare personnel trained from accredited training centers. These training sessions should not become merely a one-time activity but should be a continuous process depending upon the patient input in different healthcare facilities.
- There should be strict implementation of waste management rules and defaulters should be explained the importance of the waste management.
- All staffs should be made aware of the formal system of reporting of hazard due to BMW.
- It should be made compulsory that an injury should be reported to the concerned authorities so that appropriate measures can be taken.
- It should be ensured that the injuries happening to the healthcare personnel are reported to the biomedical waste management committee, and they report it in the prescribed format to the pollution control board.
- Regular monitoring and training regarding handling, segregation, transportation and storage of biomedical waste as per their color code are highly recommended at all levels to deal with this burning issue of biomedical waste.
- Public awareness about BMW and the importance of its segregation from general waste needs to be addressed.

- It is crucial that COVID-19 waste management follows environmentally sound principles and practices of BMW management with safe work- and infection-control practices.
- Segregation of COVID-19 waste at the source, awareness, use of sustainable technologies, and precautions at all steps of the waste-cycle is the only way ahead in this crisis.
- Special emphasized should be given to training of health staff. In present study majority of the sanitary staff workers did not have any training on biomedical waste management.
- All the participants in our study felt the need of having biomedical waste management and handling as part of the curriculum.
- The medical officer should create awareness among paramedical staff and sanitary staff regarding bio medical waste management in primary health centre and also motivate them to do good practice of biomedical waste management.
- Further studies should be conducted at a large scale by including different levels of health facilities.

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Summary

SUMMARY

- The present study entitled "A study on Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities of District Ghaziabad" was conducted in health care facilities of rural area of Ghaziabad city."
- This is a health centre based cross-sectional study, carried out in the Government health facilities in district Ghaziabad i.e. Community health centre (C.H.C), Primary health centre (P.H.C), Sub-centres and Department of Community Medicine, Santosh Medical College, Ghaziabad, UP.
- The aim and objectives were to Assess the Knowledge and Practice of Biomedical Waste Management among the Health Care Workers of Health Facilities in District Ghaziabad, to find out associated factor with their knowledge & practice regarding Biomedical Waste management.
- The required sample size came out to be 122. Proportional allocation scheme was used to select the required number of health care workers from each facility.
- Stratified sampling technique was used with proportional allocation scheme. The total sample size was first stratified on the basis of educational qualification of the respondents and then on the basis of health care facilities where the respondents were posted.
- There are four blocks in district Ghaziabad, in each block there is one CHC, under each CHC there are four PHC. The total number of sub-centres in these four blocks are 145. Data was collected randomly from 4 CHC, 12 PHC and 50 Sub-centres.
- A semi-structured, pre-designed, pre-tested questionnaire for in-depth interview of the study population was used as the tool for data.
- The following important observations were made:
- The present study was carried out in 66 government health care facilities, which include 4 CHC, 12 PHC and 50 Subcentres.
- Out of total 122 health care worker 26 (21.3%) were from CHC, 46 (37.7%) were from PHC and 50 (41%) were from sub-centre.

- Of the total 27 doctors,18 were from CHC and 9 were from PHC. Of the total 75 nurses, 50 were from subcentre, 21 from PHC and 4 from CHC. Of the total 6 Lab technicians One lab technician was from CHC and the remaining 5 from PHC. Regarding the 14 sanitary staff 11 were from PHC and 3 from CHC.
- Majority of the HCW were in the age group of 31-40 (50%) followed by 41-50 (30.3%), 21-30 (13.9%) and 51 and above (5.7%) respectively.
- Majority (78.6%) of the study participants were female and 21.3% were male.
- Most of the HCW were diploma holders 71(58.2%) followed by graduates 25 (20.5%), post graduates 13 (10.7%) metric pass 10 (8.2%) and 12^{th} pass 3 (2.5%).
- The Knowledge among the health care workers regarding precautionary measure of BMWM was 82.7% and Practice was 59.1% among the HCW.
- The knowledge of the health care workers was a tad bit better (62.2%) than the practices followed (50.8%) by them.
- In the present study,111(91.0%) of the health care workers were aware of the term Biomedical waste management and 11 (9.0%) were unaware.
- Only one fourth of the health care worker (34.5%) knew that the rules of bio medical waste management were first proposed in 1998, which comprises half of the doctors (51.9%), two third of the lab technician (66.7%), about one fourth of the nurses (29.3%) and only 2 (14.3%) of the sanitary staff.
- Regarding the revision of biomedical waste rule and regulation, we found that 16 (59.3%) doctors, half of the lab technicians (50%), almost one fifth of the nurses (19.7%) and about one fourth (28.6%) of the sanitary staff knew correctly that the Bio medical waste management and handling rules were revised in 2016.
- Awareness regarding different colour coding of the Biomedical waste, was best among the sanitary staff 14 (100%) followed by the nurses 73 (97.3%), doctors 26 (96.3%) and lab technician 5 (83.3%) respectively who were aware about the same.
- We found a total of 73 (59.8%) health care workers knew about the correct agency (state) that regulate biomedical waste.

- Our study revealed that, 115 (94.3%) of the health care workers were aware of biomedical waste hazards.
- Majority of the health care workers (83.6%) knew that both Hepatitis and HIV/AIDS can be caused by Bio medical waste if not disposed safely.
- All of the doctors, Lab technicians and Nurses while 92.9% of the sanitary staff were aware of the precautionary measure to be taken while handling biomedical waste.
- All the doctors 27 (100%), lab technicians 6 (100%) and Nurses 75 (100%), 12 (85.7%) sanitary staff think that wearing a PPE can reduce the risk of infection.
- Any hazardous event while handling biomedical waste should be reported in 24 hours was known by 13 (48.1%) doctors, 2 (33.3%) lab technicians, 22 (29.3%) nurses and 3 (21.4%) sanitary staff worker in our study.
- In this study, doctors (48.1%) have most and sanitary staff (21.4%) have the least knowledge of correct thickness of plastic sheet provided inside different bins.
- In this observational study only a meagre (5.7%) study participants were correctly aware that the waste ought not be kept for more than 48 hours, while 42 (34.4%), 67 (54.9%) and 6 (4.9%) said it to be 12 hours, 24 hours and 72 hours respectively.
- Nearly half (48.4%) of the health care workers knew that pretreated vacutainer was handed over in Red category waste.
- More than three fourth of health care workers (77%) in our study knew that the general waste should not be collected in yellow colour coded bins.
- Majority of the health care workers (77%) were correctly aware that segregation is most important aspect of biomedical waste management.
- In this study, 51 (41.8%) health care workers knew that incineration is the treatment for yellow bags.
- Laboratory waste is pretreated on site before sending for final disposal was correctly answered by 18 (66.7%) doctors, 4 (66.7%) lab technician, 30 (40%) nurses and 1 (7.1%) sanitary staff.

- The correct symbol for Biohazard waste was identified by 77.8% doctors followed by lab technician (66.7%), nurses (57.3%) and (35.7%) of the sanitary staff, which came out to be (59.8%) of the total health care workers.
- About half of the health care workers (54.1%) knew how to correctly prepare 1L of "1% Sodium hypochlorite from available 5% strength".
- In this study, health care workers could not match the different colour coding, as 101 (82.78%) of the health care workers did not know the correct colour coding under the revised 2016 biomedical waste management and handling rule.
- Only 36.1% of the health care workers knew that pollution control board of India is responsible for the safe transportation of the biomedical waste.
- In the present study 98 (80.3%) of the health care workers said that the biomedical waste management was properly followed in their setup.
- Regrettably, 23 (18.9%) of the health care workers reported that the revised biomedical waste management rules were not followed in their setup.
- The practice of segregation of different types of waste was followed by all of the doctors and lab technicians but not followed by 17 (22.7%) of nurses, 3 (21.4%) of sanitary staff.
- In this study 11 (9%) of the health care workers reported that new colour coding is still not being followed in their setup and 44 (36.1%) were not aware of the new colour coding rules.
- Majority of the health care workers (79.5%) knew that the biomedical waste is to be collected in separate colour coded bag.
- In this study 25 (92.6%) doctors 5 (83.3%) lab technicians, 47 (62.7%) nurses and 7 (50%) sanitary staff workers were labelling the hazardous waste separately.
- A total of 55 (54.9%) of the various health care workers were weighing and 67 (45.1%) were not weighing the biomedical waste in their health facilities.
- Most of the study participants 87 (71.3%) were wearing PPE and 35 (28.7%) were not, while handling biomedical waste.
- Puncture proof containers for sharps waste were used by 25 (92.6%) doctors, 6 (100%) lab technicians, 50 (66.7%) nurses and 7 (50%) sanitary staff.

- Majority of health care workers 105 (86.2%) were storing the biomedical waste for not more than 48 hours which is the correct time limit as per the handling rule. Those not following were 15 (20%) nurses, 1 (3.7%) doctor and 1 (7.1%) sanitary staff worker. All lab technicians were following the correct time limit of storage.
- One third (33.6%) of the health care workerswere using appropriate plastic sheets of 50mm for the biomedical waste management.
- Majority 88 (72.1%) of the health care workers were having a system of reporting injuries and accident due to biomedical waste.
- In this study 86 (70.4%) health care workers were reporting any hazardous event due to biomedical waste management within 24 hours.
- All of the lab technicians 6 (100%), 25 (92.6%) doctors, 60 (80%) nurses and 8 (57.1%) sanitary staff workers, were immunized against Hepatitis B.
- After needle stick injury or percutaneous injury, it was observed that 101 (82.8%) were taking but 21 (17.2%) were not taking the post exposure prophylaxis.
- Worryingly 34 (27.9%) of the health care workers were putting the infectious waste in black container.
- Nearly one fourth (28.7%) of the health care workers knew the correct preparation for 1% for Sodium hypochlorite for biomedical waste management.
- Majority (70.5%) of the health care workers were following the good practice of maintaining a register in their health setup. However, the register was not maintained by a substantial number (29.5%) of health care workers.
- Nearly one third (32%) of health care workers said that a private agency while almost half of them (47.5%) said that a state agency, is assigned for safe transport for biomedical waste management.
- Regarding the COVID-19 knowledge and practice following observation were made.
- It was seen that 13 (48.1%) doctors, 3 (50%) lab technician, 22 (29.3%) nurses and 4 (28.6%) sanitary staff workers, knew that goggle, face shield and gloves used in COVID 19 are to be disposed in red bins.

- In this study,11 (40.7%) doctors, 2 (33.3%) lab technicians, 39 (52%) nurses and6 (42.9%) sanitary staff workers, were correctly disposing the used COVID 19 protective equipment like mask in yellow bin.
- A little less than three fourth (58.2%) of the total health care workers including 16 (59.3%) doctors, 5 (83.3%) lab technicians, 44(58.7%) nurses and 6 (42.9%) sanitary workers correctly knew about the use of double layered bags for collection of COVID-19 waste.
- In this study, 77 (63.1%) and 26 (21.3%) of the health care workers knew to dispose off COVID-19 waste in 12 hours and 24 hours respectively, the latter being prescribed method.
- In the present study, 32.8% health workers said correctly that the plastic overall used were disposed off in red bins.
- More than half (58.2%) of the health care workers correctly knew that the inner and the outer surface of biomedical waste container from COVID-19 must be disinfected daily with 1 % Sodium Hypochlorite.
- Only 14 (11.5%) of the health care workers didn't know that COVID-19 waste bag and container need to be labelled while 25 (92.6%) doctors, 6(100%) lab technician, 7 (9.3%) nurses and 5 (35.7%) of sanitary staff workers knew about this mandate.
- COVID 19 BMW is the name of the application developed by the state pollution control board was known by only 29 (23.8%) of the health care workers and most of them (46.7%) were unware about it.
- Deep burial as the preferred method for disposing COVID 19 waste from remote quarantine centre was known by 52.5% health care workers while 6 (4.9%) and 4 (3.3%) thought it to be microwaving and recycling respectively.
- Among the 86 (70.5%) of the healthcare workers who were using separate colour coded bin with foot operated lids for COVID 19 waste disposal, the maximum were doctors (92.6%) and the minimum were sanitary staff workers (64.3%).
- A separate record for COVID 19 waste generated was maintained by 17 (63%) doctors, 4 (66.7%) lab technicians, 44 (58.7%) nurses and 2 (14.3%) sanitary staff.

- A total of 51 (41.8%) of the staff did not have dedicated sanitation workers deputed only for collection of COVID 19 biomedical waste and 71 (58.2%) had the dedicated sanitation workers.
- Exactly half (50%) of the total healthcare workers had and half (50%) had not attended any government certified training regarding hospital waste management. Notably majority of the sanitary staff workers 10 (71.4%) and doctors 17 (63.0%) had not attended any government certified training regarding Hospital Waste Management.
- Two third of the health care workers 84 (68.9%) had a facility for storage of Biomedical waste in their centers but 38 (31.1%) did not have one.
- Banners/charts showing biomedical waste collection, segregation and disposal, were reported to be present by 23 (85.2%) doctors, 5 (83.3%) lab technicians, 56 (74.6%) nurses and 9 (64.3%) of sanitary staff workers, at their health facilities.
- A significant association was found between education level and general knowledge of biomedical waste management. Knowledge of graduate was almost five times higher 4.863 (1.729-13-675) than diploma holders.
- Doctors had three times higher 3.371 (1.310-8.675) general knowledge of biomedical waste management than nurses.
- General knowledge was almost five times higher 4.825 (1.703-13.671) among the CHC staff and two times higher 2.311 (1.017-5.250) among PHC staff than sub-center staff
- A significant association was found between occupation and Total knowledge of biomedical waste management. Knowledge of doctors had three times higher 3.274 (1.119-9.579) total knowledge of biomedical waste management than nurses.
- Total knowledge was five times higher 5.5 (1.655-18.278) among the CHC than sub-centre staff.

- A significant association was found between education level and general practice of biomedical waste management. General practice was four times better 4.086 (1.458-11.453) in graduate and 4.301 (1.090-16.974) in post graduate than diploma holders.
- Doctors had five times better 5.029 (1.722-14.686) general practice of biomedical waste management than nurses.
- General practice was seven times better 7.467 (2.404-23.194) among the CHC staff and two times higher 2.765 (1.209-6.324) among PHC staff than sub-centre staff.
- A significant association was found between education level and practice regarding handling rule of biomedical waste management. Practice regarding handling rule was six times better 6.045 (1.883-19.411) in graduate and 6.33 times (1.308-30.661) in post graduate than diploma holders.
- Doctors had thirteen times better 13.542 (2.992- 61.289) practice of handling rule in biomedical waste management than nurses.
- Practice was eight times better 8.974 (2.679-30.056) among the CHC staff and three times higher 3.059 (1.330-7.038) among PHC staff than sub-center staff.
- A significant association was found between practice regarding hazard in biomedical waste and gender. Practice regarding hazard was five times better 5.023 (1.410-17.90) in males than females.
- A significant association was found between education level and practice regarding hazard of biomedical waste management. Practice regarding hazard was four time better 4.308 (1.34-13.837) in graduate than diploma holders.
- Doctors had twenty times 20.42 (2.633-158.477) better practice regarding hazard in biomedical waste management than nurses.
- Practice regarding hazard was thirteen times better 13.0 (2.772-60.975)) among the CHC staff and almost three times higher 2.750 (1.177-6.423) among PHC staff than sub-centre staff.

- A significant association was found between education level and practice regarding precautionary measure of biomedical waste management. Practice regarding precautionary measure was six times better 6.045 (1.883-19.411) in graduate and 6.33 (1.308-30.661) times better in post graduate than diploma holders.
- Doctors had thirteen times 13.542 (2.992-61.289) better practice regarding precautionary measure in biomedical waste management than nurses.
- Practice regarding precautionary measure was twelve times better 12.509 (3.302-47.380) among the CHC staff and three times higher 3.059 (1.330- 7.038) among PHC staff than sub-centre staff.
- A significant association was found between education level and total practice of biomedical waste management. Total practice was five times better 5.160 (1.832-14.533) in graduate and 8.963 times (1.844-43.558) in post graduate than diploma holders.
- Doctors had eight times higher 8.161 (2.566-25.956) practice of biomedical waste management than nurses.
- Total practice was twelve times better 12.833 (3.770-43.690) among the CHC staff and almost three times better 2.778 (1.201-6.422) among PHC staff than sub-centre staff.
- A significant association was found between education level and occupation with Knowledge of COVID 19 of biomedical waste management. The odds of this knowledge being good in 10^{th} pass healthcare workers were low 0.144 (0.029-0.732) as compared to the diploma holders.
- A significant association was found between education level, occupation and health facilities and practices of COVID-19 waste management. The practices were three times better 3.859 (1.378-10.811) in graduate and four times 4.062 (1.030-16.024) in post graduate than diploma holders.
- Doctors had more than three times better 3.595 (1.304-9.908) practice of COVID-19 biomedical waste management than nurses.

- Similarly, the CHC's COVID 19 biomedical waste management practices were more than four times 4.440 (1.482-13.974) better than subcentres.
- There were lower practices regarding precautionary measure and handling rules for biomedical waste management (59.1% and 58.1% respectively) despite the knowledge being higher for both of them (82.7% and 68.3% respectively).
- In contrast, there was poor general knowledge regarding bio medical waste and knowledge regarding their hazards (51.6% and 57.3%), despite better practices on both of these parameters (54.9% and 66.3% respectively).
- Good knowledge of the health care workers was 62.2% but among them 22.9% were following poorer practice.
- Poor knowledge of the health care workers was 37.7% but 11.4% of them were following good practice.
- There was a week positive correlation between knowledge of biomedical waste handling rule with practice of biomedical waste handling rule. ($r=0.338$, $p=0.007$). and knowledge regarding biomedical waste hazards with practice of biomedical waste hazards ($r=0.276$, $p=0.029$) This signifies that better the knowledge, better will be the practice.in both these instances
- This study also revealed that the knowledge of precautionary measures was inversely co related ($r= -0.051$) with its practice. However, it was not found to be significantly correlated ($p=0.694$).

Annexures